UNVEILING TRANSPARENCIES

CLOTHING THE INVISIBLE

MASTER THESIS IN ARCHITECTURE

Claudia Fleischmann

Chair of Affective Architectures - Prof. An Fonteyne

Chair of History the History and Theory of Urban Design - Tom Aver-maete

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INTRODUCTION

Glass: The History

In the realm of architecture, glass has been long revered for its ability to dissolve boundaries between interior and exterior, offering the comfort of protected indoor spaces, while keeping the visual continuity to the outside. Its transparency is often used to symbolize modernity, openness, and even democracy – which itself can be problematic, if not applied in the right context or as a hollow façade when the building and institution behind remains obscure and deflects, rather than offer a clear view. Furthermore, glass nowadays as well as in the past symbolizes power, influence, and wealth. Large skyscrapers today are wrapped in glass curtains, towering into the sky like shards, a dome of a government building enabling its citizens to stand above the plenary hall. Contrary to a democratic symbolism of the German Parliament today, Versailles showed in the past the power of the King through its large halls made of mirrors and glass. Louis XIV. founded specifically the glass workshops of St. Gobain as a mean not to depend on the glass makers of Murano for the project of the palace and establish a glass trade of its own in France.

Glass was only able to become such a widespread used material in construction today due to the technical advancement of the last century, towards an affordable large-scale, industrial production. Before the 20th century glass remained a material reserved for the elite. The processes of production were intensive in land use and labour wise, which made it expensive. First, because in Central Europe during the Middle Ages up to the 18th century whole forests disappeared, not only to fire the kilns but also to produce ash as an additive to lower the melting temperature of the glass. For one kilogram of raw glass, around 400 kilograms of wood were needed. Before an industry existed in Europe, the art of glass making during the Roman Periods spread mainly around the Mediterranean. The access to the sea would provide algae as ash or in the case of Egypt even natural soda.

Second, in terms of labour it required multiple steps to arrive at the desired glass product. The manufacturing process would also differ from

the quality (i.e., the clarity) needed. For example, glass that is blown by a glass pipe needs a higher viscosity, which is only achieved by higher heat or a double melting process. Back in the day before the use of coal, these temperatures could not be reached, and a system of double melting was established by the Romans. Large furnaces were found in the region of Syria, where glass would be melted into large blocks to be later transported to smaller glass workshops. Window glass in Roman times was produced by pulling and rolling the hot glass, which later needed to be polished.
The glass manufacturer established by the French King Louis XIV. in 1665, introduced a roll casting technique, where the molten glass was poured on a special table and rolled flat by a large barrel operated by a group of strong workers. Thus, the glass would have needed to be only polished on one side, which was still a long process.

Later, an industrial adaptation of the cylindrical blowing technique was used in the 19th century to build large glass houses, such as Paxton's Crystal Palace in London.
Since then, the industry has moved on from artisanal techniques, abstained from the use of wood. The furnaces went to be fired by coal to fossil fuels. Additives such industrially produced soda and dolomites are used in the mix to lower the melting temperatures. The processes in the float glass production are mostly fully automated. It has become a material today that is removed from physical labour to a large-scale production without much human involvement. However, the transformation of sand to a transparent, almost liquid material, remains today intensive in terms of energy and resources. As a high-temperature endeavor, glass production demands vast amounts of energy and is connected to a high loss of heat. While there are already systems of recuperating some of this heat, mainly in the float factories, there are still large unused potentials, especially further downstream.

Float glass is produced close to the availability to silica sand and thus, there are no such factories in Switzerland. The second phase of processing, however, is located closer to the final market, as it is expensive to transport finished glass products. Consequently, 'raw' flat glass is imported from the European Union in large, standardised sheets, to be processed inside one of many handling factories in Switzerland.

Point of Entry

In this Thesis, I look more closely to one of these spots of further processing, specifically a branch of Glas Trösch. Among other processing steps, here the glass is reheated again to hight temperatures to become complex glass products, which are later on used in the construction sector. The excess heat created in production is later emitted to the surrounding environment, remaining unused and wasted energy.

Site

The primary site is located in an industrial zone, sitting between the two cities of Gossau and St. Gallen. It opposed by the three large building volumes of the Glas Trösch facility, of which each is covered in different glass techniques and typologies. The site of the project is embedded into the agricultural landscape of productive fields of the municipality, and is easily accessible by public transport. National hiking and bicycle roots run through or alongside the borders of the site.

Objective of the Thesis: Heat

Heat is energy set free, from physical labour, from living itself. In industrialised processes, complex machines generate heat as a biproduct, or do so by burning or heating things. Glass is 'born' in heat and 'evolves' in heat.

The Thesis looks more closely at the potential that lies in the unused excess heat of the processes in industrial glass production in Switzerland, more specifically in the facilities for glass processing. It draws the connection of the heat used and emitted in the production chain, to the heat that is enabled by the specific material properties of glass. In greenhouse architecture, the glass wall serve the purpose of growing plants in ideal conditions, beyond their seasonality and/or local availability.

In conclusion, the work at hand is proposing a solution on how waste heat can be made of use for efficient agricultural crop growing in greenhouses, by extending the seasonality or enable the growth of subtropical plants.

Project: Housing Green

The project elaborated follows the heat: emitted by the 600°C oven, the heat is transmitted to a carrier liquid, which is commonly water in district heating systems. The water is then pumped through a system of pipes, fed into a network that connects the facility of the glass producer with the greenhouse on the opposite street. The connection between the glass production facility and the greenhouse is emphasised by the visibility of the infrastructure of pipes, while the building is organised according to the piping and heat distribution.

The initial Project of the greenhouse sets a dialogue on our relation to local 'productive' landscapes and import of foreign plants, while responding to the materiality of glass. It provides a look on what we usually see through, making the glass and its development, production process is influencing the environment. The greenhouse serves as a research centre and case study alike, to show the potential of farming in an urban context, drawing from excess industrial heat. By the shape of the building, the intangible heat is given a form and embodied in the growth of the plants.

A second aspect of the project is aiming at reducing glass waste of the cutting processes in the glass facility. This is done in two ways: first, using glass that has imperfections in greenhouse architecture in general, as it was still common practice 50 years ago. Second in optimizing the cutting processes, by implementing small sized glass sheets for the construction of curtain like façades, as implemented on the north facing façade in the proposed greenhouse, allowing it to be a prototype for similar façade developments.

Giving shape to Urban Heat

The correspondence of the dependence of food grown in greenhouses, and the possibilities it opens for self-sustaining urban communities is emphasised through the suggestion of smaller scale interventions in the city of Zurich. These interventions are similar in the architecture of greenhouses, as they provide shelter for plants and enable additional green spaces for the population. As the large greenhouse in the context of the Glas Trösch facility, these intervention are provided by heat sources, that remain (often) unused. It opens up possibilties on different scales, drawing from the heat exausted by small servers in architectural offices, to residential extensiones in the vicinity of bakeries or even running to large-scale additions of greenhouses next to data centers.

They make visible what usually stays hidden in plain sight, what we as humans in urban environements overlook - the glass curtains we are often surrounded by and the heat we emit with our daily ways of living.

SCOPES

Europe

Glass in its development over the centuries to its high-tech state as a building material, as well as in its production nowadays should be considered in the larger scope of Europe and the Mediterranean region. Flat glass factories are usually set up close to silica sand mines. Thus, all the raw flat glass is imported to Switzerland before processed to higher product.

In terms of history, we look east, where first it is presumed glass making had its origins.

Switzerland

Until the 15th century, glass was imported from Murano or the Black Forest region in Germany. Emigrated crafts man would later bring their knowledge to Switzerland and establish the roots of a glass production in forest rich regions all over the country.

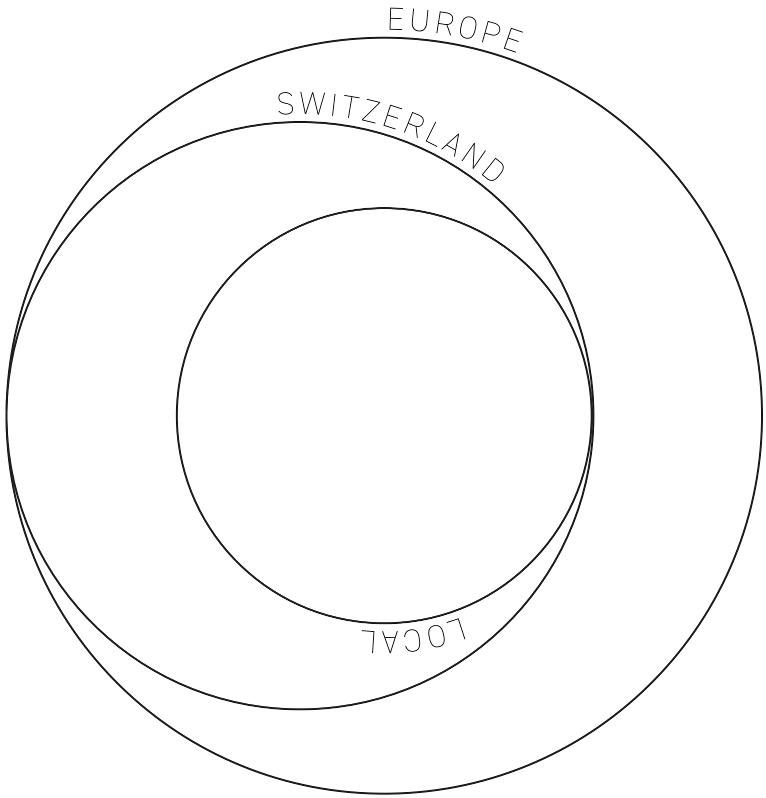
By the late 18th century, coal as fuel, industrial soda and foreign sand for its quality were imported for a growing large-scale industry. The Waldglashütten (forest glassworks) became obsolete, replaced by a mechanized industry as wood gradually became scarce and the local sand was of poor quality. The glass factory of Moutier was the only factory that produced flat glass. However, it had to close its door finally in 2017, as the production was too small to be viable in today's economy.

In general, due to the high competitiveness and maintenance of mass production in the glass industry, almost all businesses that operated glass furnaces (mainly packaging) had to cease their operation by the 20th century.

Today, glass factories in Switzerland do not produce flat glass, instead they process imported float glass. It is coated, shaped, cut, assembled, painted etc. In this Master Thesis, I look toward these middle stations of glass production where simple flat glass becomes a product we know in our windows and are confronted with every day. These facilities are numerous and scattered throughout Switzerland.

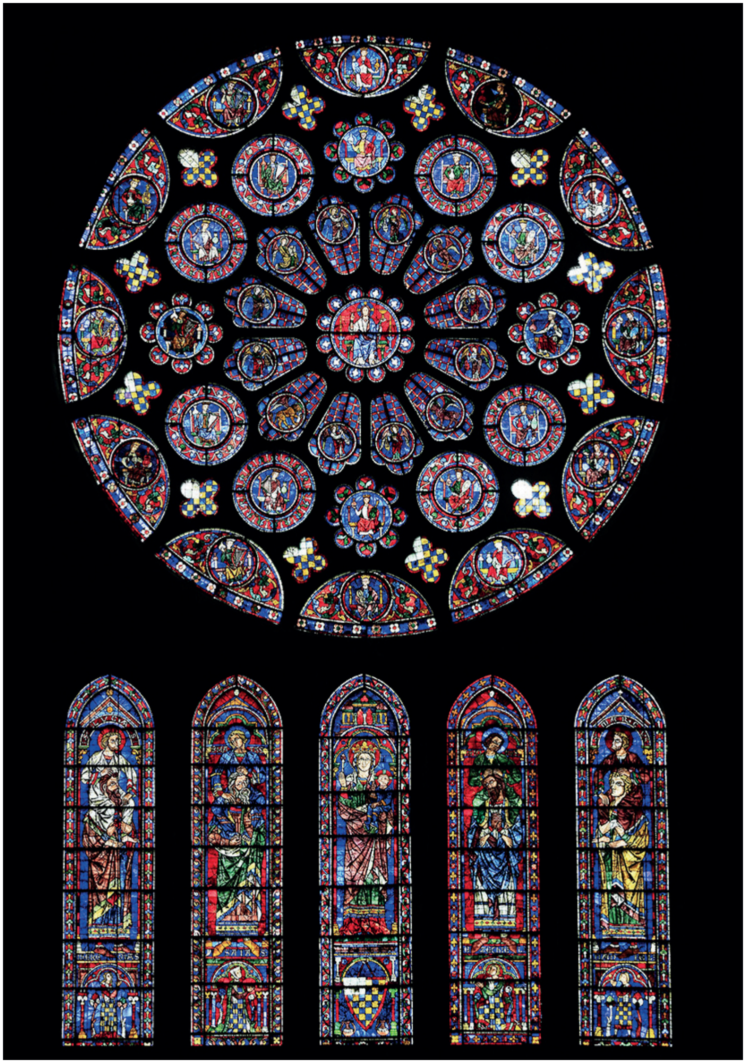
Local

Glas Trösch, Vetrotech St. Gobain, Flachglas AG, and many smaller producers operate lines



that process simple flat glass to higher glass products. These companies are in their region often an important employer, offering a variety of different job positions.
The factories are usually located in industrial quarters of Swiss villages, often placed in proximity of agricultural farmlands.

Building
The buildings follow a simple, efficient floor plan of large industrial halls. The production site of Switzerland's largest (and Europe's largest family operated) business in the glass sector, Glas Trösch, follow a particular aesthetic. Large, glass boxes, resembling greenhouses but turned blue, with a repetitive grid of the window assembly.



Notre Dames des Chartres

FROM OPAQUE TO CLEAR, FROM GREEN TO WHITE

unknown origins and complex histories

Glass is one of the oldest materials known to humanity and fascinates because of its vast variety of shapes and forms. It belongs to the non-metallic, inorganic materials. In its form it is unique as a material; when it cools down from its molten state it does not crystalize, but rather retains its liquid structure even in a solid state.
Glass occurs naturally in a variety of forms. One of the most found glass materials is Obsidian, which is created when Vulcanic magma cools down rapidly. In the early days of humanity, obsidian was used due to its sharp edges as cutting and hunting tools. Today, artificial glass is one of the most diverse materials and is used in a wide variety of industries and for a variety of purposes. The spectrum ranges from packaging material for food to the construction sector. Multi-pane insulating glass and heat-insulating glass wool improve the energy balance of buildings and contribute to climate protection. As a component of solar systems, glass makes solar energy usable. There are also other glass applications such as sheet glass, glass fibers, flat screens, or pharmaceutical containers.

If the production of glass has originated from Egypt, Mespotamia or the Levante Coast cannot be said. Oldest found glass artifacts reach back as far as 9000 BC and were found in Mesopotamia.
The art of glassmaking spread across Egypt, Cyprus, Assyria and the whole of Mediterranean in the pre-Christian period and thus developed into a prehistoric glass industry. Due to the widespread societal collapses of the bronze age around 1200 BC, glass production came to a halt, and was picked up again later around 900 BC. Around the same time, techniques were developed to create colourless glass with a special type of ashes from sea grass, which was later adopted by the glass makers of Venice in their secret ways of producing the clearest glass over centuries. In 200 BC, Syrian craftsmen developed the glassmaker's pipe which simplified glass production and increased its scale. The further development of the cylinder stretching process made it possible to produce flat glass panels as early as the first century AD, which were mostly used in the thermal

baths and palaces of the emperors of the Roman Empire.
However, it was later discovered that in small scale housing a technique of pulling and rolling was used to create glass sheets for windows.
The oldest recorded recipe of a composition for the mixture of glass comes from the library of the Assyrian king Ashurbanipal which dates to around 650. The rough proportions of sand, lime and ash as an additive is comparable to similar rations throughout the centuries and to modern day glass production.

By the time of the Romans and throughout the Middle Age, mass glass production was split into primary and secondary workshops. In the first phase the sands, ashes and other additives were molten in large melting furnaces into large glass blocks. Usually, the production of these blocks took place around the origins of artificially glass production, the Levante coast, Egypt, or Syria, where remains of large furnaces were found.
The blocks were then transported to the secondary workshops all over the empire to be shaped into the final hollow forms, such as vases but also windows.

The two-step system was necessary as high temperatures over 1000° are necessary to produce the thin viscosity glass mass which makes is eligible for glass blowing. These temperatures could not be reached yet. However, the first production step of melting it first into raw glass blocks made it possible to use lower temperature in the second step. The contemporary practice of using glass cutlet to lower temperatures in the cross-fired furnaces is comparable to this Roman technique.

After collapse of the Roman Empire, glass workshops continued to operate in the same tradition of glass blowing workshops. In the Middle Age workshops were set up increasingly in forest, as they started to use the ash as an additive instead of the naturally sourced soda from Syria or Alexandria. The additive of the wood led to the typical green colour of the round moon glass, which was mainly typical in central Europe, such as the Schwarzwald and later too in certain regions of Switzerland, such as the Jura or the Entlebuch. The practice of using ash as an additive led to large clearings of forests and in some regions to ban glass production. This made it a highly exclusive and sought for material and contributed to its symbol of power and wealth.

An important invention of the baroque period was the roll-casting process to produce plate glass in France. The glass manufactory of St. Gobain in France was founded by Louis XIV. to be independent of the glass makers of Venice and to supply for mirror halls in Versailles. Still at that time, the production was complicated: the roll-casting needed polishing after, which made it a labour-intensive process. Up to this time glass remained a luxurious material and became only affordable to the masses with the introduction of coal burned furnaces and industrial techniques and machines from the late 19th century onward.

(tl) pulled and rolled Roman glass found in mainly housing
(bl) wood glass process (mond glas) using ash from the woods
(tr) roll casting process in St. Gobain
(br) Mirror Hall in Versailles with polished mirrors prodiced in St. Gobain

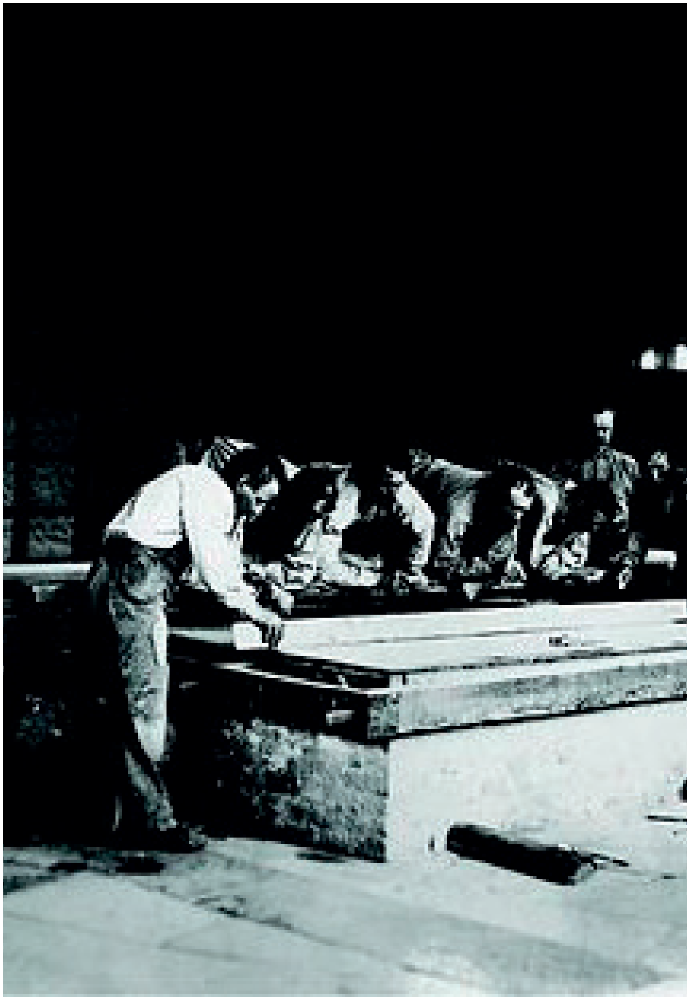
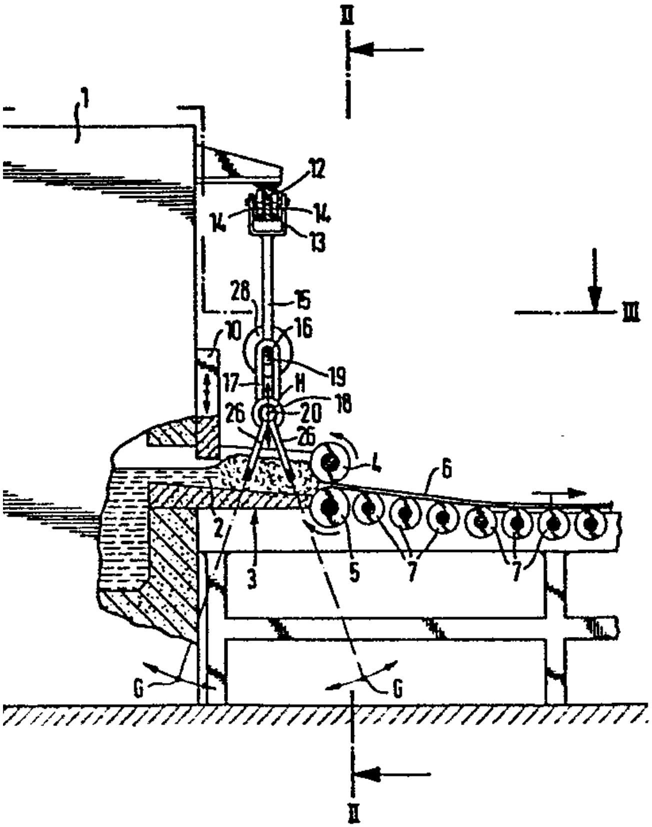
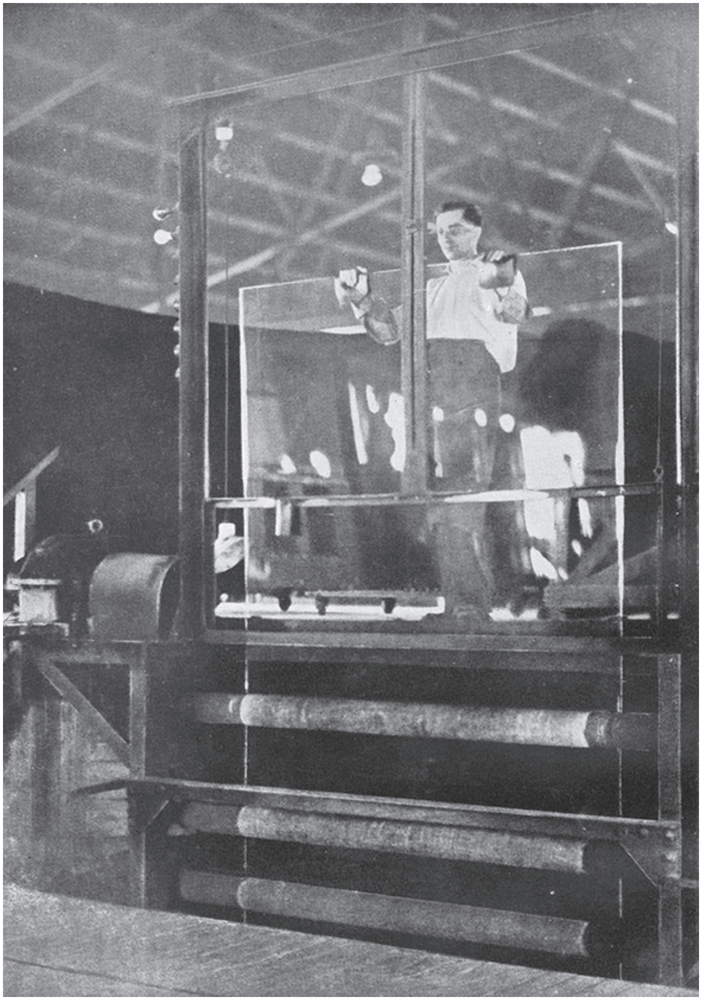


Fig. 1





Glass Production in St. Gobain,
roll-casting table in the late 19th century
Contemporary roll-casting glass machine
Fourcault Pulling Machine

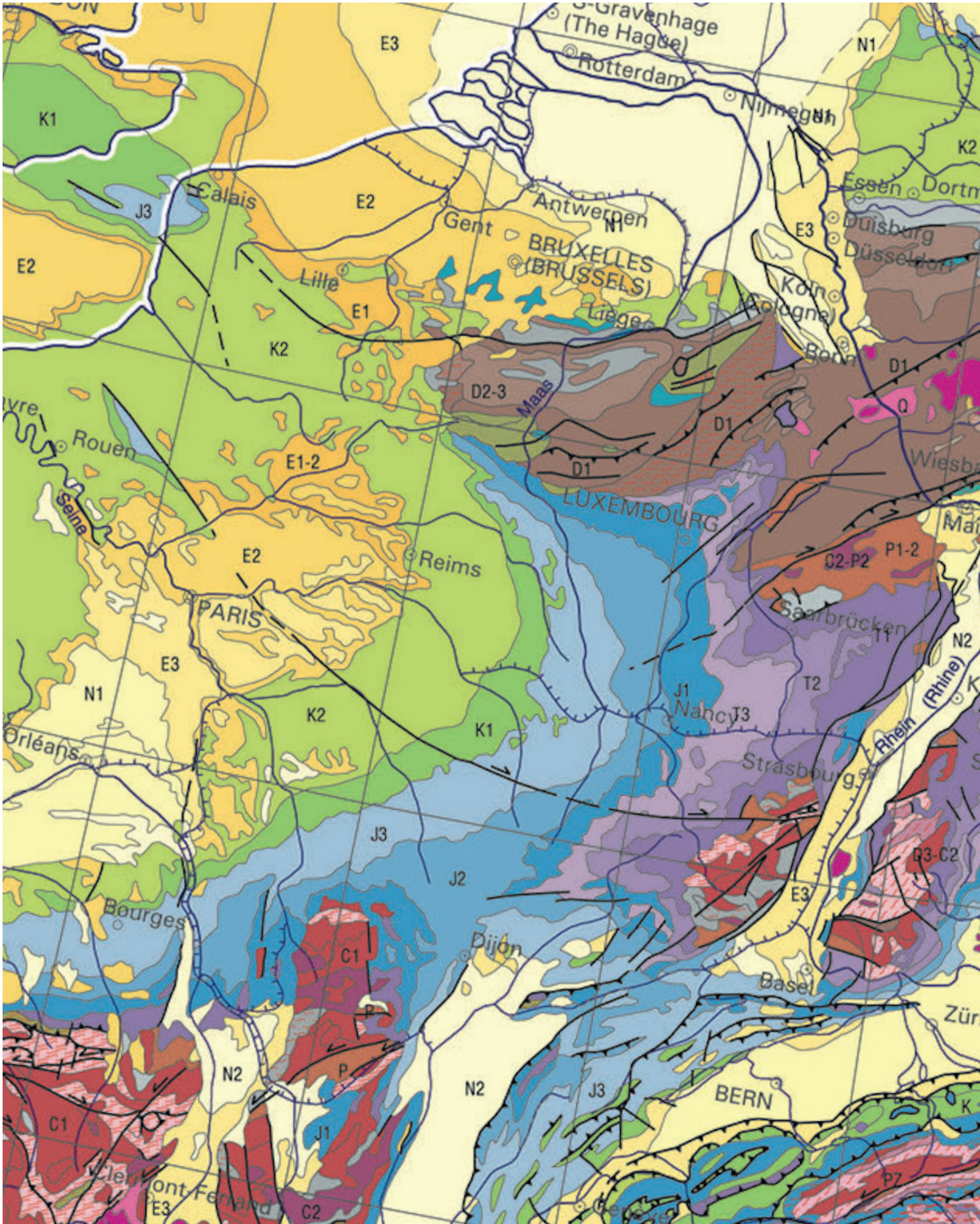
Raw Material added to the oil fired furnace
Glas Trösch Flat Glass Plant

CONTEMPORARY FLOATGLASS PRODUCTION

born in heat - tied to geography

Most flat glass that is used in the European building sector stems from a strong root within the continent. Over 90 % of the raw materials come from Europe (mainly silica sand is imported from China), which is then processed in 48 float glass factories. Across the entire industry sector - from sourcing to processing the glass into finished glass products such as security glass - over 100'000 positions are filled, ranging over a broad field of different expertise.
The largest glass company in Switzerland Glas Trösch is operating four float glass production sites in Germany, France, and Poland. There no such factories in Switzerland, due to the limited availability of silica sands within the borders of Switzerland itself.
There have been smaller quarries that have been operated in the past century, such as the sand quarry near Benken ZH. It was abandoned after the municipality declined an additional permit to clear the forest for further mining in the 1980 and now it has become an important natural reserve. It delivered its sand to the smaller glass factories across Switzerland such as Glasi Hergiswil and Glashütte Bülach, of which the latter had to close soon.
If compared to amount of float glass produced today, the quarry couldn't hold up to the required amounts of silica sand. Annually, 11 000 tons of sand were mined from the quarry. Today in an average float line 650 tonnes a day of float glass are produced daily which means annually that over 140'000 tons of silica sand are needed.

Flat glass manufacturing is one of the highest temperature processes in the industry sector, recycled glass and sand must be heated up to 1600 C°. Such high temperatures are necessary to minimize defects, which alter light transmissions and influence the properties of the glass. Special furnaces have been developed over the centuries to achieve such high temperatures.
These large melting units are often cross-heated regenerative tanks powered by natural gas. 70% of the Co2 emissions generated by the float glass production are alone from the burning of fossil fuels in the melting furnace. Due to the rise of gas prices since February 2022, the industry in-


's-Gravenhage
(The Hague)
Rotterdam
Nijmegen
Essen
Calais
Antwerpen
Gent
BRUXELLES
(BRUSSELS)
Lille
Liège
Köln
(Cologne)
Bonn
Duisburg
Düsseldorf
Rouen
Seine
Maas
LUXEMBOURG
Reims
PARIS
Saarbrücken
Nancy
Strasbourg
Rhein
(Rhine)
Orléans
Bourges
Dijon
Basel
BERN
Clermont-Ferrand
E3
N1
K1
K2
J3
E2
E1
D2-3
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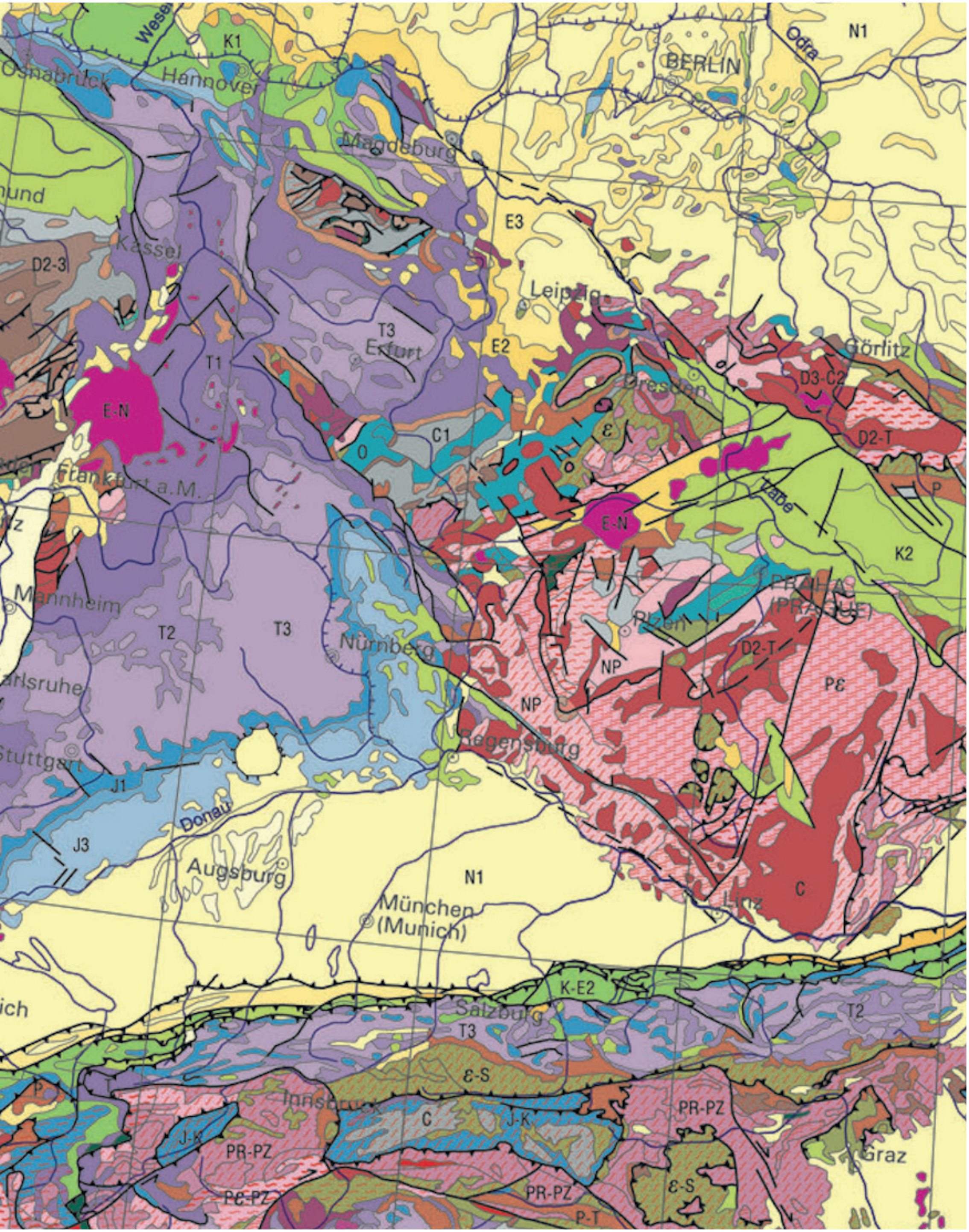
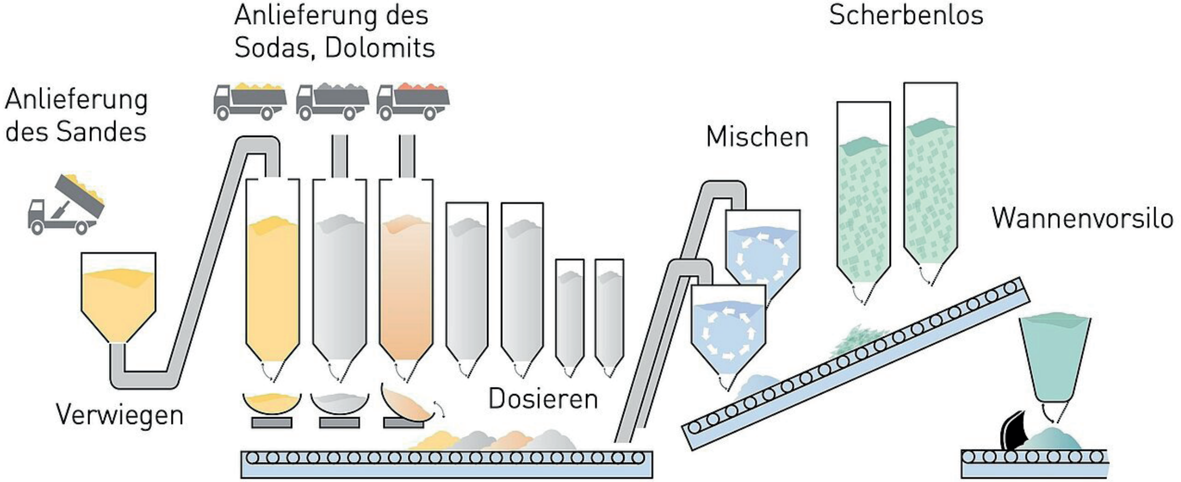
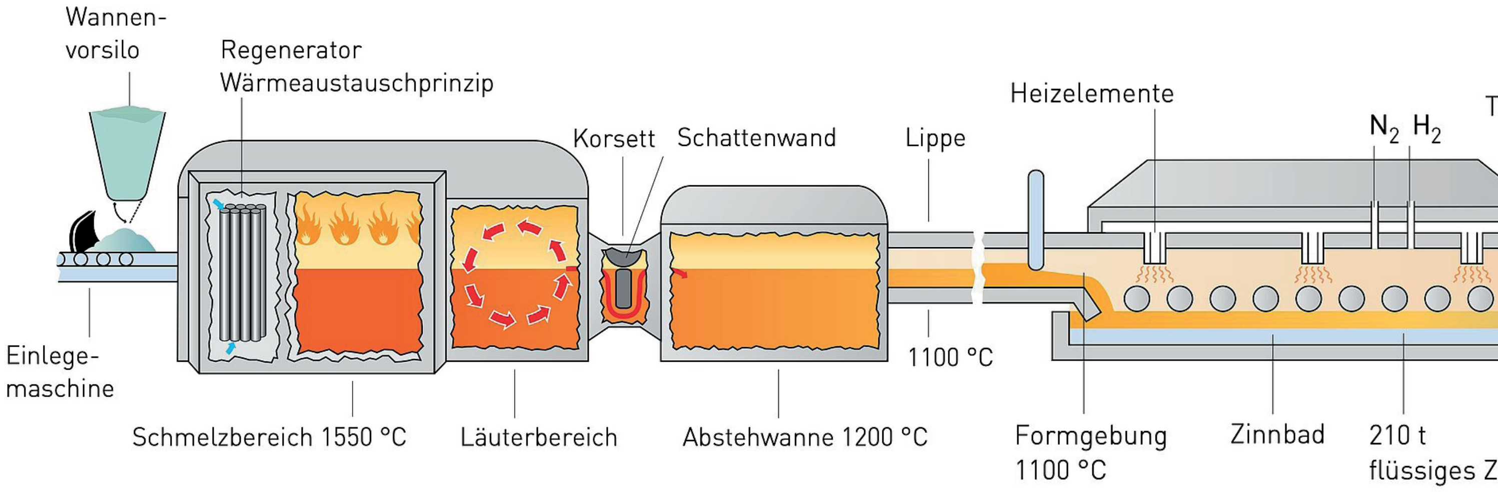


Geological Map of Europe

Abandoned silica sand quarry in Benken ZH
After the quarry had been closed and all the buildings demolished, the empty site was turned into a natural reservoir - an important sanctuary for plants and animals.


Anlieferung des
Sodas, Dolomits
Scherbenlos
Anlieferung
des Sandes
Mischen
Wannenvorsilo
Dosieren
Verwiegen


Wannen-
vorsilo
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Wärmeaustauschprinzip
Heizelemente
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Schattenwand
Lippe
N_2 H_2
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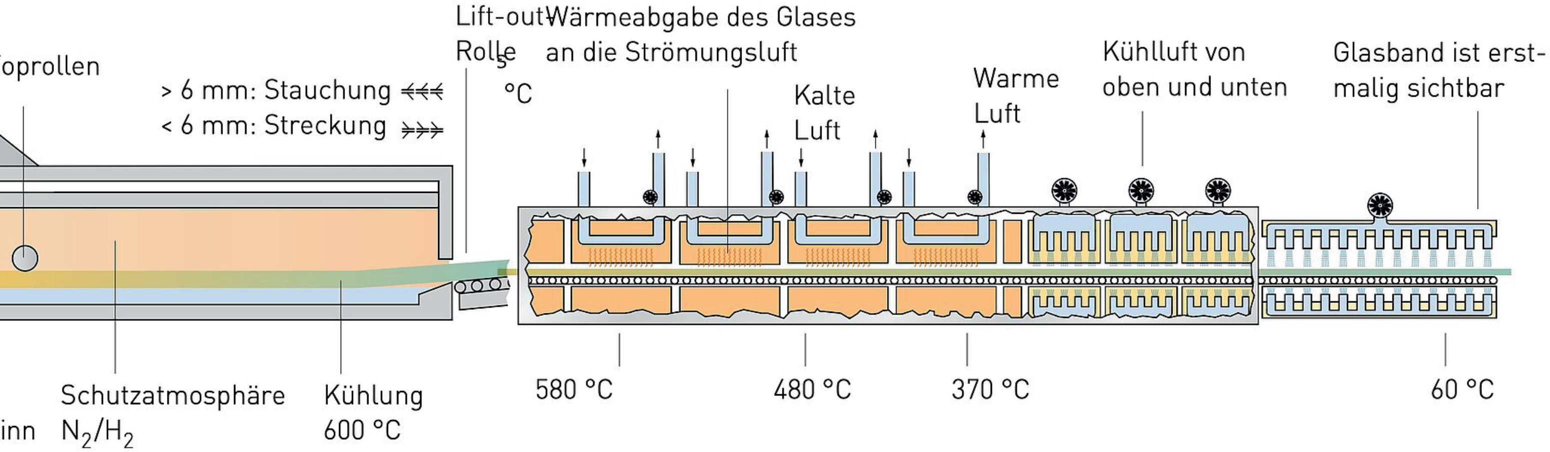
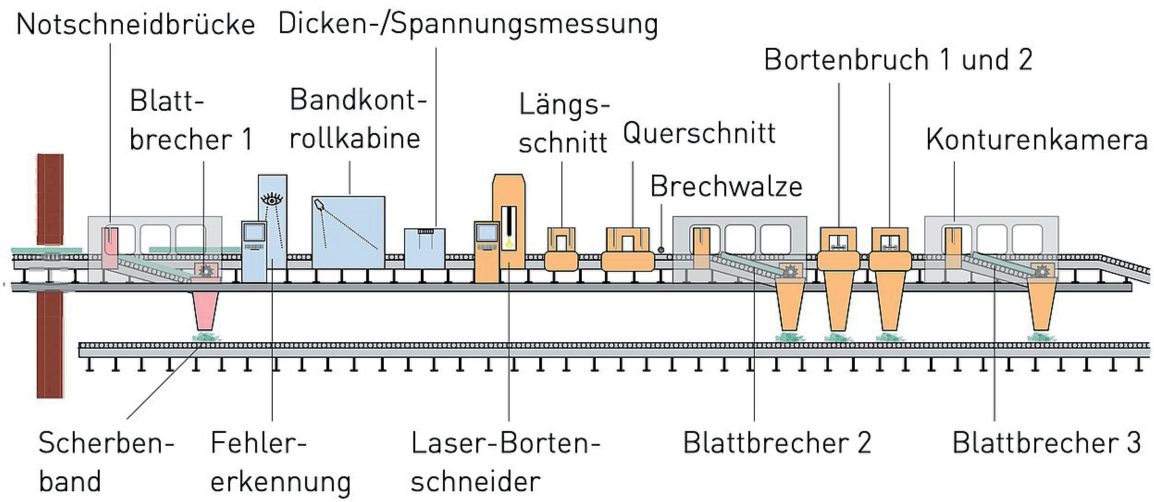
maschine
1100 °C
Schmelzbereich 1550 °C
Läuterbereich
Abstehwanne 1200 °C
Formgebung
1100 °C
Zinnbad
210 t

troduced the ‘Glashüttenzuschlag’, which was added to the material price and is connected to the fluctuations of current oil prices.
Regenerators are heat exchangers that alternately absorb heat and release this heat back into the combustion air. This means, some of the heat that is emitted can be used back in the process. However, there is still an overall heat loss of 0.8 PJ annually, which equals to the annual heating load of 9000 households.

After refining the molten glass is transferred to the tin bath. Due to the lower density of glass, it ‘floats’ on the tin, hence the name. The speed of the glass ribbon is controlled by top-rollers, which gives the glass the desired thickness. Naturally, it would result in a 6mm thickness, with the top-rollers a spectrum between 3mm and 20 mm are possible.
Gradually, the tin bath cools down and transfers the glass to the cooling line, after which it will be cut in uniform sized sheets of 600 cm x 321 cm.

Float plants are the most expensive production centres of the glass industry. A typical float glass line averages around 600 meters in length and runs around the clock, every day of the year. A typical lifespan of a melting furnace extends to 20 years, which means technical advancements, such as implementing electrical melting possibilities, are only introduced slowly. Modern electric furnaces do exist, but they are hardly compatible yet with melting loads above 200 tons.
Although the modern idea of floating glass on a much denser material is documented already very early in patent history (reaching back to





the early 19th century), the technical prerequisites did not exist, which would have enabled the high-volume float process. Some of the conditions, such as the large-scale production of the hydrogen gas that is required in the floating chamber were only fulfilled in middle of the 20th century, where the float glass process has been patented by Pilkinton.

There are no clear numbers on how much heat is generated by the ovens and heating processes in the production factories in Switzerland. However, by asking different actors within the processing sites and comparing to other industrial processes, there would be easily enough heat to use externally the factories. The idea of a district heating system here comes to mind.

There has been different approaches and strategies to further make the process of float glass production more efficient, which are well stated by the DENA, the German Agency for Energy in 2022 and their document for reducing CO2 Emissions in the glass production industry. However, this is mainly focusing on the large float glass lines. Through the observations and collection of information, it has been clear that the focus has also to shift downstream to the local processing sites, where the sheet glass is processed into tempered security glass.

Storing of finished glass plates

ON THE BORDERS

The second phase of glass production takes place closer to the end market and the consumer, i.e., the building sector. In Switzerland, there are a multitude of glass processing factories, which process ‘simple’ float glass to more complex glass products. Beside the glass, other products are included in the production of (yet frameless) windows, such as spacers, foils, and gas.

The factory in Gossau near St. Gallen serves as an entry point to the whole glass production cycle. It operates as a middle point, between the ‘raw’ glass ribbons and the finished, framed windows put in either buildings or vehicles. In this glass processing unit security glass and isolation glass is produced from the large uniform sheets of float glass.
The three glass buildings are located at the outskirts of the municipality of Gossau, facing the open fields of productive agriculture on the other side of the street.

Protocol of a visit (September 2023)

Inside, me as visitor find myself in a safety yellow jacket and goggles, with the phone secured in the pocket (since taking pictures was not allowed). Stepping into the first hall, a wall of warmth hits the skin on the face. The architect that led the tour already warned me beforehand of the heat inside the first plant. Through this whole visit I am accompanied by an artist friend interest in the materiality, looking upon glass with the same fresh eyes I had before I started this journey. With curiosity, with my notebook in my hand, we kept in step with our guide.

In the middle of the hall the source of the heat is located; it is the oven which heats the sheets of float glass up to 650° and cool them down rapidly again. With this procedure, the viscosity and crystalline structure of the glass changes, making it more resistant to external damage. The glass coming out on the other hand is called VSG (Vorgespanntes Sicherheitsglas); tempered safety glass.
Other machines, like the oven for the laminated security glass or the large submarine like auto-

glass processing plant , Büzberg BE

clave are also producing excess heat. We are told, the excess heat is used in winter to keep all the indoor spaces warm. However, it is so much, that there is still a lot of it given to the outside. To the question of an estimate, Herr Amplatz answers with a compelling image: that around the plant, it could be all year around summer. A fact, that would be of importance to me, as the notion of heat in the process of glass production was one that stood out from the beginning. What could make use of the heat that is no longer used?

The first hall included many other machineries; a sanding machine that smoothed out the edges in different way, which produced milky white bubbly water. Others were more sophisticated computer operated CNC machines, that would cut out complex patterns. While being close to the machines I was also wondering why we didn't get a protecting for our ears. The banging, cutting and breaking of glass was sometimes deafening.

Usually, the big sheets of float glass are delivered to the first hall by special trucks. The glass gets stored there in tall racks, walking beside them made a slight anxiety rise through my chest, as I realised how massive the material can be in certain sizes. While trying to deal with my claustrophobia, Mr. Amplatz was explaining how heavy single sheets of glass are and told the story of a large double-glazing window that was weighing around a ton. It never occurred to me to consider the weight of windows but being in presence of such large-scale products made it a fact that would be hardly ignored from now on.

The glass panels ordered in the right thickness


Windegg
Held
Silthang
Schloss
723
648
Segeten
665
A1/E60
642
Oberdorf
651
Bachwisen
Oberdorfbach
Hafnersbergbach
645
Heimat
Rainhalden
Bruggwis
647
Vorderrain
700
715
Rain
Hinterrain
Waldegg
Rosenberg
740
721
727
Lehn
687
Oberrain
739
Roserwald
738
Schochenberg
814
800
766
715
Hueb

Location of the glass processing factory near Gossau / St. Gallen

(varying from 3-12mm) would then be cut: first, a programmed computer arm would scratch the surface. Then, on the other end of the table, one or two persons would operate the breaking part. The special table has air flowing from below to make the glass easily liftable (somehow this reminded me of the air hockey tables). It supported the worker in breaking the glass in easy movements, often leaving cut-offs in different sizes. Their practice seemed effortless as they were throwing the cut-off pieces blindly behind their back into the large bins, always scoring.

After, the cut to size pieces of glass were either processed to the laminated glass line or directly to the edge sanding, if they were processed for tempered security glass. After the glass has been tempered it is no longer possible to cut or to sand, since it would immediately brake, as the edges are the weak point of the glass.
In the laminating lines, the sheets would move into another large spaceship-like module. This was the room where the foil would be sandwiched between the two glass panels. As the foil is sensitive to humidity and any kind of dust, they must work in a clean room under strict requirements. After, the sandwich of glass panels and foils gets transported to a different oven, which is the first process to 'glue' the sheets together. In the final step before sanding the edges, the glasses are transferred to the large submarine called 'autoclave'. The machine operates with negative pressure to eliminate last bubbles between the layers and press them together.

From the first hall over an outdoor passage the second one stands wide open, and a little bit less secretive, as it is clad in full green-house style glass panelling.
Two large lines cross the 100-meter-long facility, both responsible to turn single glasses into complex systems of isolation glasses. Of course, we find here also a large cutting table, as well as fully automated one, on which we look down from a little bridge that crosses a river of broken glass cut-offs.
From there, the cut glass is put into the process to build sandwiches of finished insulation glass packets, that are further then shipped to a framer or directly to the building site.

Protocol of a Visit – Flachglas AG(October 2023)

It is my second visit to a glass processing site. This time however, I am welcomed into complex by a different company, Flachglas AG in Wikon. Joel, a responsible for fire security glass leads me into a seminar room, prepared for my visit.
The conference room was set up with all the different components that go into the production of glass, and a variety of different glass products - from simple glass to sandwiches of laminated and coloured glass, the possibilities seem endless.
Beforehand visiting the factory building, Joel had prepared a presentation on the whole production chain as well as on the company, and its

values. Turns out, even if it was sold to Pilkinton later, it was established early in the 20th century and has deep ties in the Bernese Hinterland.
A striking and unique feature was a sideboard like structure with different isolation glasses embedded into the surface and red glowing heating lamps below. The difference between a single sheet of glass and double insulation glass is astonishing, whereas between double and dripple glazing it is almost not perceptible. This illustrates perfectly that triple glazing is often not the primary choice, and often doesn't offset its production emissions by the energy that is saved. The gain is minimal.
After the introduction and a repetition of the material I already had a deep dive in, it was time to visit the production lines of laminated glass and insulation glass. They would not yet produce tempered security glass, however, expect the delivery of the respective oven by the end of the year, as the company changed owners hands.

This time, I was not in a yellow security jacket, but a blue lab coat and a matching helmet (the company's colours). My phone was also hanging around my neck, it seems there isn't much of a secret kept after all (or was it just the novelty of a student being interested in their line of work?).
The atmosphere was different from my first visit as well: the hall was cool (absence of the ovens) and dark, it didn't faze me as sterile as in the first company visit. The geometry of the factory building was common to the industry quarters it was placed it, a large volume clad in corrugated iron, the sounds echoed therefore and were not as muffled.
Was Glas Trösch a snow landscape with the snow swallowing the sounds (not literally, but it didn't have the metallic ring to it), Flachglas resembled the rough mountain landscape in the summer heat.
We walked through the large hall, with carts of sheets of glass planted in random order, waiting to be either picked up, or further treatment. The first station was operated by two men, again the table with the air lifting up the large planes and cutting them into smaller piece. Here they were listening to music, and seemingly in the rhythm of the base drum, one was breaking of the glass pieces, throwing away the cut offs blindly into the large bin located in his back.
Moving on, we visited the clean room for the laminated glass, but the two workers were unfortunatly already off, as they normally start very early and stop before 3 PM. The machines were similar, not that I could tell the difference. I still found the submarine, aka the autoclave the most fascinating machine in the whole hall.
Moving on, the isolation lines in the next hall were the similar, nothing new in my eyes. Operated by one person controlling the glass sheets for the last time before they get sealed and the gas is put in.

When we came to the end of the line, we arrived at two big pressure chambers - They are a piece I didn't knew before, but makes sense: the pressure chambers are designed to put the finished insulations glasses inside to adjust the inside pressure of the windows to match the one of the

building located at high altitude. If they wouldn't do this step, glasses could shatter due to negative pressure.

Protocol of a Visit – Glas Trösch, Various Locations (October 2023)

Traveling one day all over Switzerland, I discovered various sites of the Glas Trösch company.
Fire glass processing site in Buochs was located on a wide plane and seen from the right angled it fit perfectly in the middle of the valley deepening of the tall mountains in the background.
In Büzberge it seemed, as if the whole little village consisted of Glas Trösch buildings. Considering it is their headquarters, it seems logical. Here, as in all other locations I encounter the same typology, and the closeness to the agricultural land.

Protocol of a visit – Glasi Hergiswil (October 2023)
Besides looking into the glass production in the construction sector, I also took a closer look into the artisanal tradition of glass blowing. A key example in Switzerland is the Glasi Hergiswil, with a history going back to the 19th century. The region around Hergiswil accommodated back in the day a large part of the national glass industry, however, was getting unpopular with the time, as whole forests were disappearing to the extensive need of wood.
It was fascinating to observe the glass makers with their work, while feeling the heat of the large ovens of melted glass. Interestingly, the hall has remained the same over the time, while the machinery inside had changed. The contemporary oven is running as well 24/7. The operation here stays in stark contrast to the industrial production of flat glass, as it is relying on human labor as well as allowing the visitors coming close and see how actual glass products are made.

"Ripe Pineapple with Dido Longwing Butterfly" in Metamorphosis insectorum Surinamensium

TAMING THE PLANTS

The special properties of glass, as light transmission, protection, and the separation of the outside climate, made it the ideal material for building botanical glass houses from the 17th century on. Exotic and heat sensitive plants from warmer and more humid climates would not be able to survive in these Nordic latitudes. By dissolving the wall into a large panelling of glass windows it became possible to accommodate, grow and breed plants from all over the globe in Northern climates such as in Switzerland.

Rare plants from far-off places became increasingly a presentable status symbol and a tool of colonialism in the 18th and 19th century, led by the world power England by then. Botanical gardens played an increasingly important role of establishing control over the newly acquired territories, for examples introducing ‘cash crops’ such as tea, coffee, and rubber in new colonies, to which these plants were not native to, but able to grow.

Bringing back to the homeland exotic plants in return meant also representing the ‘successes’ of colonial exploration and literally the power to control nature, by building environment and develop strategies to cultivate foreign tropical plants.

The pineapple was the emblematic fruit to express wealth and power rooting in the Imperialist era. Back in the 17th century when the pineapple was first imported to Europe, the special appearance of the pineapple gave it a mythical quality, which could be connected to social values and prestige. Its “golden crown” enhanced the “symbolic manifestation of the divine right of [the] king”

Early attempts were made to grow the pineapple in orangeries, which proved not working as they would not provide enough heat and light during the winter months. After the development of hothouses in the 18th century, to have the staff and particularly the money to grow the plant, it meant this act of botany was a hobby only carried out by the aristocracy.

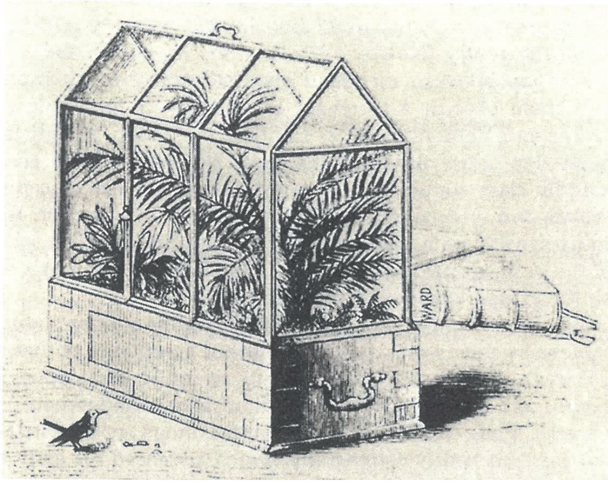
To have a homegrown pineapple by then, there were several hurdles to be overcome, which made it an expensive fruit, that would not be simply wasted to eat but be presented proudly and

additionally often guarded by security guards. The phenomenon was imported to the whole of Europe and became later popular in Switzerland too.

The architecture of the hothouse was mainly facilitated by the combination of steel and glass, that became at the time easier to manufacture and used in larger scale buildings. The Crystal Palace later built and designed by Paxton is an emblematic example for this marriage between the two materials. By that time, the industrialised process of the cylindrical blown method was developed and made the scale of the project with much less labour possible.

There are similarities to be drawn between the Pineapple and glass as material, not just in the way that one facilitates the existence of the other – but also of their symbolic characteristic, as they both were an expression of power and wealth.

Originally, glass houses were simple, functional buildings and were not subject to architectural rules and design. During the Baroque period this changed, since there was a yearning for 'other' and 'exotic' worlds, in a more natural context that is not bound to the rigid geometrical forms. In perspective, it seems a bit counterintuitive then, to build a greenhouse that consists of strong lines and glass. It was the intention of the time, to make these houses look like ruins, blending

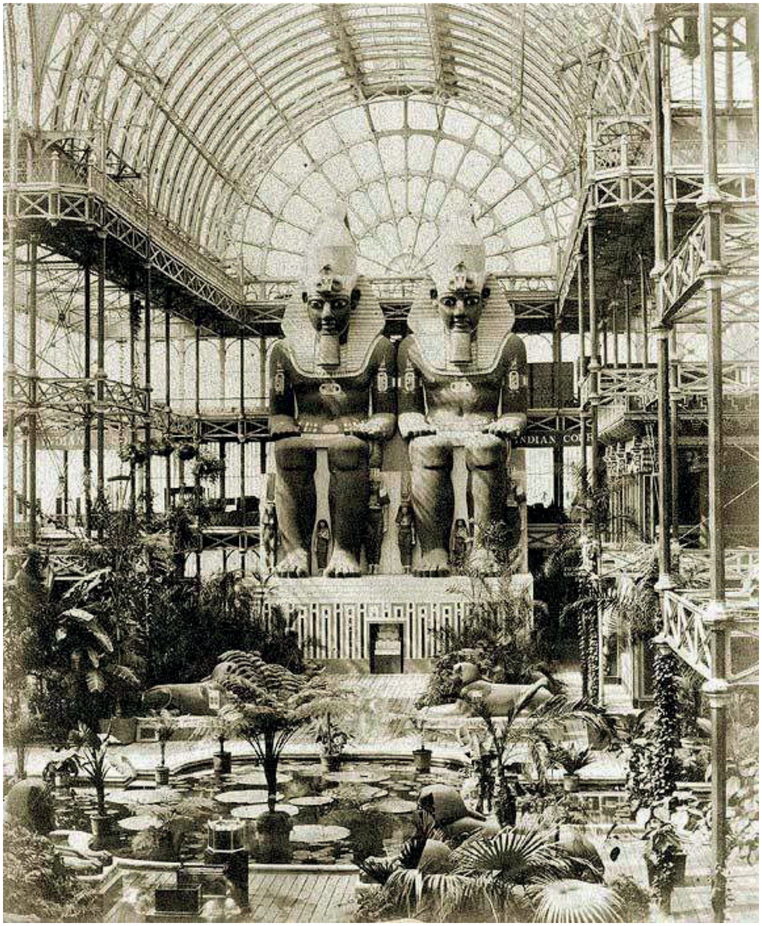


a. wardian case; transport of exotic plants

DIE ANANAS
AM ZÜRICHSEE.

b. exhibition on the pineapple sukkulentensammlung

d. 19th century orangerie and greenhouse in Oberhausen near Thun



world exhibition at paxton's crystal palace

into the natural garden. Later, evolving from gothic elements to classic motives of the ancient Greek architecture the glasshouse was liberated from its only practical design to a representative architecture. Mid 18th century classicist architecture and its need for clear structured architectural elements were fitting perfectly to the needs of greenhouse design. Later in the decade, the large palm houses gained in popularity and led to typical designs of a high space in the middle, stretching out into lower spaces on each side, or a circular matter.
The role of the architect was especially debated in the 19th century in England and France. On one hand, Loudon and Paxton were both gardeners, building many representable and largescale glass houses, such as the palm house in Chatsworth or later the Crystal Palace. Blondel on the other hand, strongly argued for the necessity of a strong architect in building of hothouses.

Looking to the sites of modern-day glass processing factories at the borders of Swiss industrial zones and villages, they either look like giant greenhouses themselves, or remind in its regular rectangular shape with a slanted roof form of the hothouse we all imagine in our heads when we think of it.
If we take this comparison further, the heat production from the ovens inside could work very well for heating a hothouse for tropical plants perfectly. They use the excess heat of the production already in heating their own buildings during the winter, however, the 680°C ovens and some other machines for the processing of glass emit the amount of heat that could be valuable for different uses too. The production factories sit like isolated heat island in the surrounding lush agricultural landscape – a branch that could profit well from the heat during the winter months. The heat could be used to extend the growth period for local plants such as tomatoes or enable the growth of non-native plants to our latitudes, such as the pineapple. Considering the Fernwärmenetz of the city of Zurich, a similar system could be thought of to be implemented in the interplay between industry and agriculture. It could lead to the establishment of a closer dialogue between the inhabitants and the industry, and deliver an educational aspect to learn about growing our basis of life and the complex reality of glass.

Over all impact of pineapple production and planting periods.

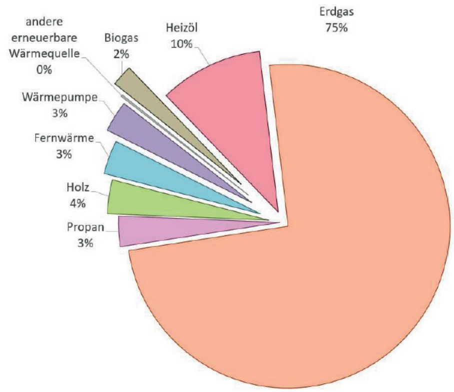
Store bought pineapple has a small negative environmental impact, that mainly stems from its monocultural, high agrochemical use, use of plastic packaging and low composting rates. However, some of them could be eliminated when the production would be shifted to a local production, even in northern latitudes by making use of industrial heat, as proposed by the work at hand.

Pineapples have an incredibly high yield of 70-100 tons per hectare, which is one of the highest of fruits. Compared to other fruits, such as strawberries or mangoes, which hold a yield around 5-25 tons per hectare, the output is manyfold higher. This means that each pineapple needs less space, therefore less land is used. In their country of origin, mainly Costa Richa, the pineapple is grown in large monoculture, which has a negative impact on wildlife diversity. This is devastating especially for the rainforest since pineapple production has grown and continues to grow rapidly.
Green house growth is not as common in Europe, which could lie in the long period it takes for pineapple plants to take root. It takes up to two years for a plant mature and produce fruit, which after then could be compensated by the high yield in later production.

Plant Periods, Heating and Energy Consumption
Tomatoes, cucumbers, potatoes, and bell peppers are vegetables that are available all year around in Supermarkets all over the country. Besides potatoes and apples that are legible for longer pe-

riods of storage, other vegetables and fruits must be imported or stem from plantation in greenhouses. However, they are also tied to planting seasons, the native seasonality is extended, instead of working on an all year around plantation schedule. Usually, the planting period for green houses ends in November. After the greenhouses are emptied out and are replanted in January, leading to fresh produce in March.

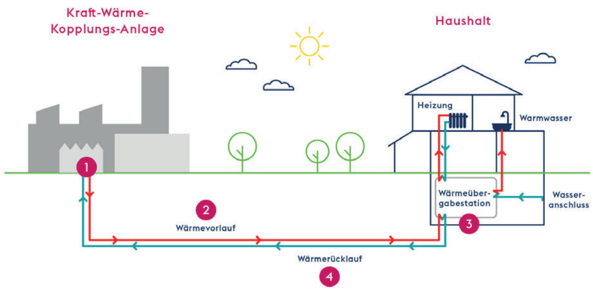
Fruits like Pineapple and Tomatoes must be additionally heated, since their ideal growing temperature lies above 20°C. For pineapples especially, it is impossible to grow them if the temperature drops below the threshold.
At 16° degrees constant temperature already 250 Kw/a per qm are used to heat a green house.
480 Gwh per Ha of additional heating power are required in Switzerland. There are estimated 300 acres of greenhouse farmland. Per acre, this equals to 1.6 Gwh/a of additional heating power. Additionally, it in about 90% it is still the case that local Swiss greenhouses are heated by burning fossil fuels, such as natural gas. This is common to the high temperature flat glass production lines, where most furnaces are powered with fossil fuel, mainly out of the same efficiency reasons and availability. Using heat from the industry could provide a possibility to reach the goals of fossil fuel free production faster. Hypothetically, such measures could lead to higher efficiency in vegetable and food production, while also offering a larger variety. This could play into the discussion of independence of the Swiss market., leading to a more self-sustaining practice. Furthermore, the change to district heating systems and other renewable sources would stabilise the overall costs of living in relation to food prices, as the heating of said greenhouses in not depended on the availability of fossil fuels.

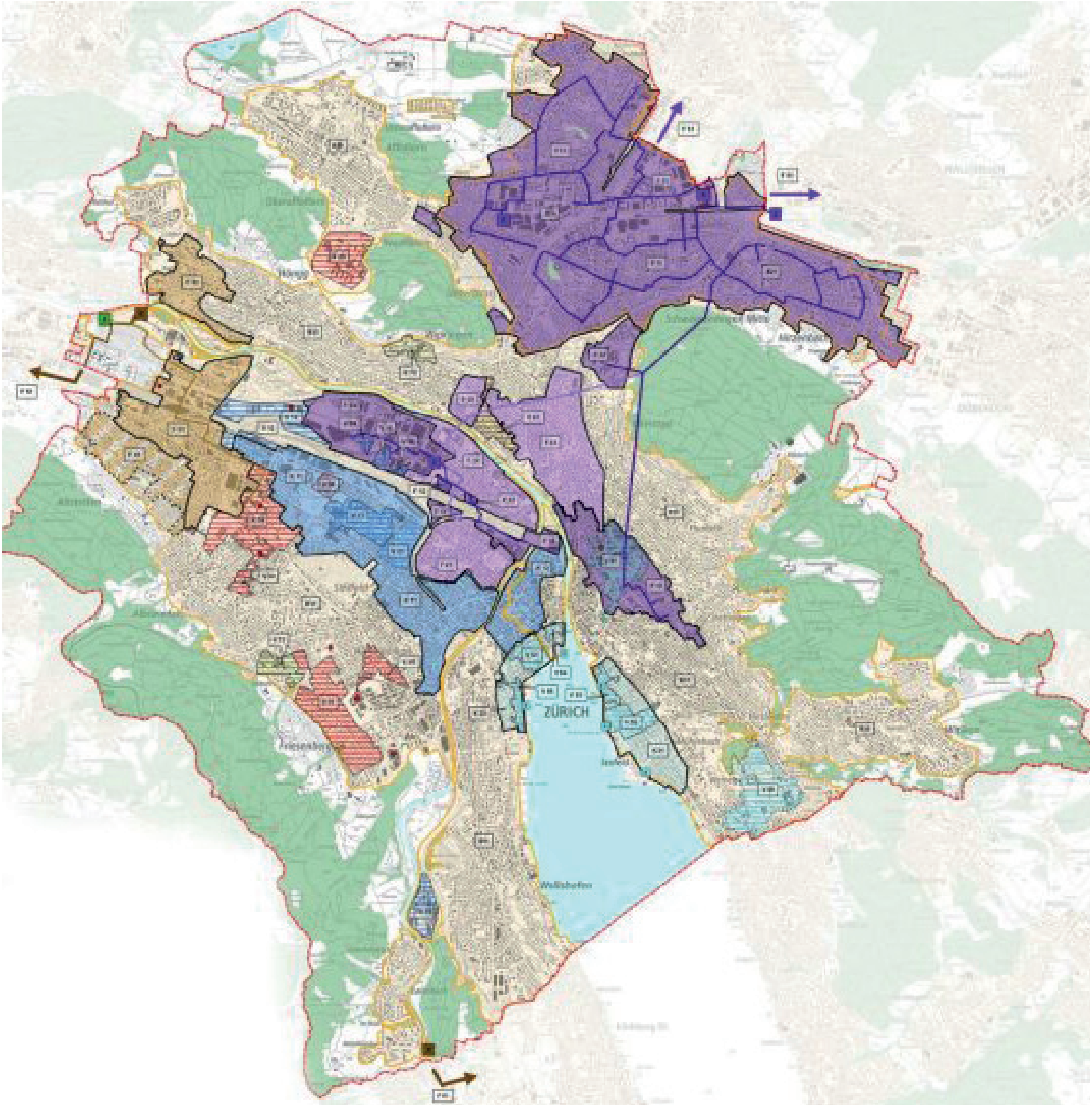


district / local heating - and opportunity

Waste heat of industrial processes has two qualities. Either through complex systems with turbines it can be transformed into electricity, or it can be directly used in close networks of insulated pipes for heating indoor spaces or water in residual areas.
The technology is already applied in various forms in Switzerland, for example the city of Zurich uses the heat produced by waste burning plants or the heat exchange of the lake water to heat indoor spaces all around town.
Technically speaking, the supply of heat from one source to only one group of recipients is not considered a district heating network. This relates more to the concept of local heating networks. In principle they work on a smaller, locale scale, eliminating large infrastructures for the heat storage and heat exchange. For example, the largest greenhouse of Germany (15 ha) in Wittenberg is heated by the excess heat of a fertilizer company.

As already put into a hypothesis, the concept of local heat networks could prove useful for the glass processing industry in Switzerland. Upon observation, many of the processing factories are located at the borders of Swiss villages, in industrial quarters, often opposing open fields of agriculture. Instead of planting only local available crops, the horizon for plants that are not native to Northern Latitudes as in Switzerland would open through the implementation of hot and warm houses. Hot and warm houses are additionally heated green houses and have been in use today mainly in botanical gardens to provide climates for tropical plants. The establishment of hot houses in close connection to the excess heat of glass processing would also provide a view on modern consumerism and the need of seasonal fruits all year around.





district heating system in Zurich (not complete,)

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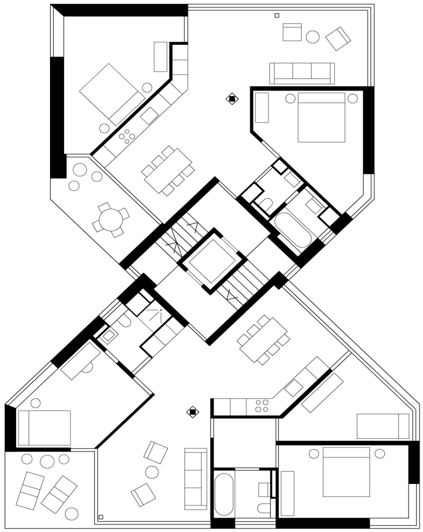
turning heat into energy

Contemporary building techniques and technologies allow to cover not only the roof in PV Panels, but also all the opaque parts of the building. The covering of the sensitive sensors with tempered security glass allows to respond to a vast variety of design choices in colour, shapes and finishings. This approach has been followed through also in the building project an apartment housing on Seestrasse, Solaris. The façade and roof were both covered completely in PV panels. The sensors were covered in a thin but structured flat glass, with the back glass laminated with a violet foil.
The complete envelope in PV Panels allows the housing complex to be completely autarch, in terms of energy demands and warm water needs. The Solaris project illustrates how broad the material is in its application and how it plays into the topic of heat and energy production.



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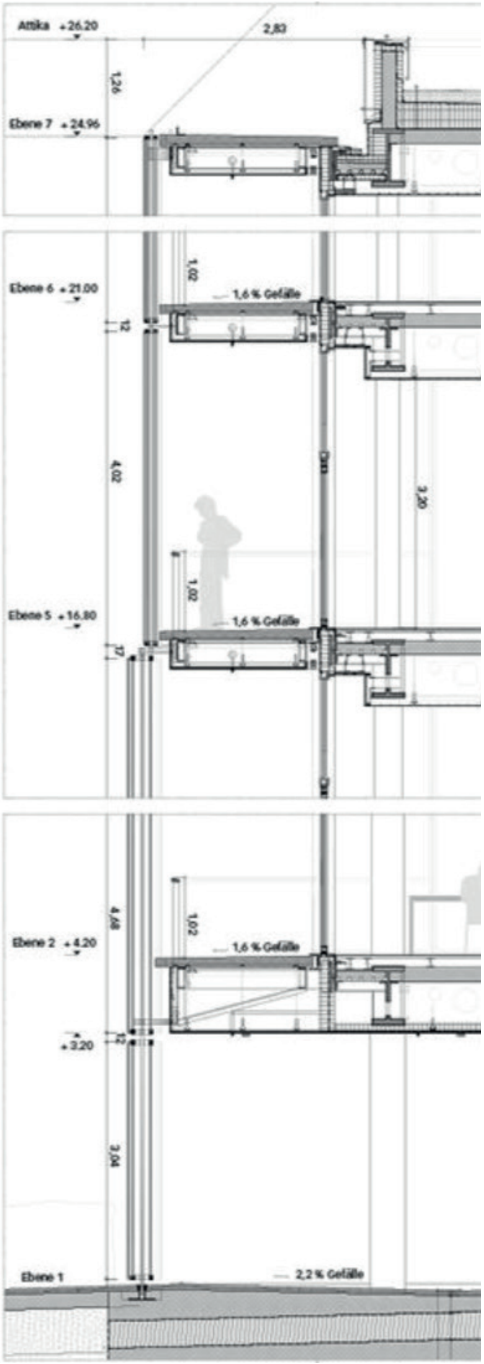
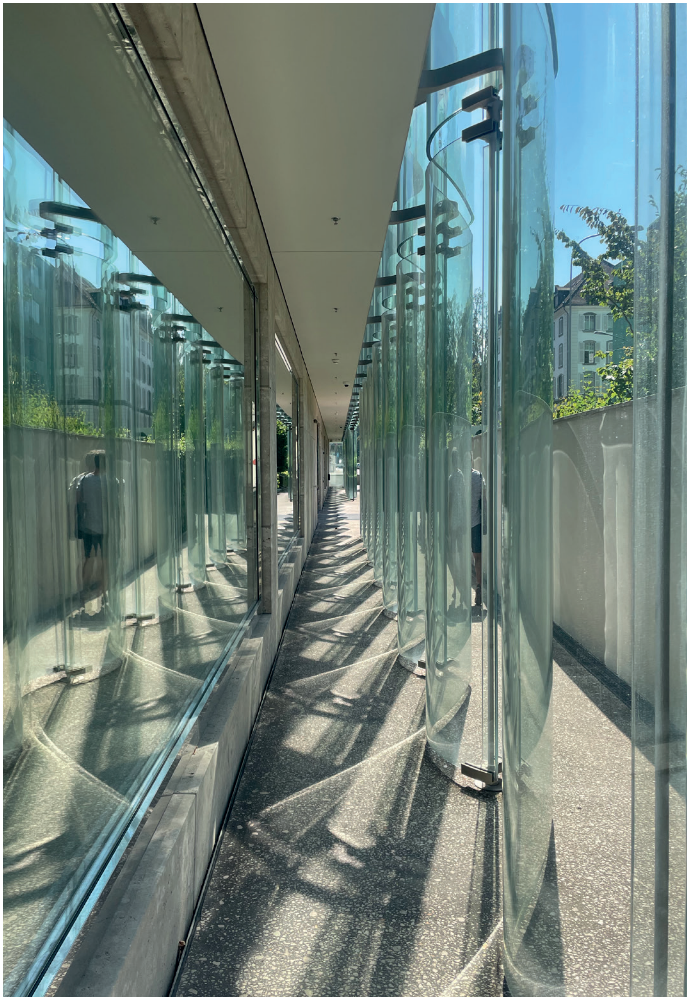
Extending the workspace

The concept of passive solar heat gains is applied too to the building of Swiss Re Next, located at Mythenquai in Zurich. It is used to circulate the warm air in summer in the space in between. In winter, the solar heat gains are used to extend the space to the outside, as an additional room for private discussions out of the open plan office or to take breakes with a view on the lake.

The Swiss Re Next building is a fine example of using the glass as a rhetoric of transparency, when it is not transparent at all, but reflects the lake side perfectly in their waved shape. In the façade mock-up, were experiments of using clear white glass, to make the appearance transparent and a visual connection from the inside to the outside. The company however decided later using a more blue and reflective finishing, eliminating the need for clear glass and the argument of a transparent company.





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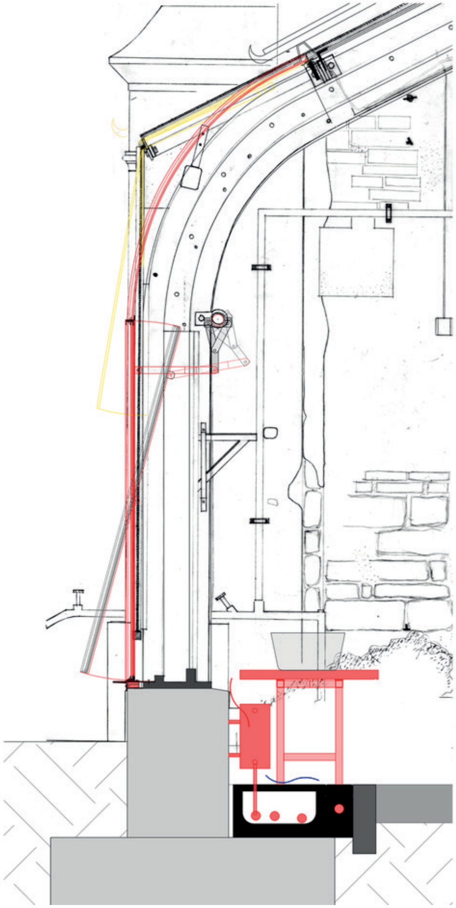
Green houses and botanic garden

A key reference for the work is the greenhouse and its complex traditions and histories. Often perceived as simply utilitarian architecture, the architecture of greenhouses evolved over time. A constant that remained throughout the centuries, was its symbolism and expression of power. Glass was a costly material to produce, and to heat the spaces additionally required money to afford the innovation and maintenance.
Today, greenhouses have become the simple geometric forms, covering the landscapes all over Europe we know when looking down from planes.

However, they can also be regarded as a real democratic space for a very essential need of human life: the food production.
It is a place too for education, informing about the wasteness of plant species all over the world and the importance of cultivating them.
As key example in Zurich is the Sukkulentensammlung, which houses thousands of species of succulents.



ORANGERIES

Orangeries are historically buildings, where citrus or other fruit trees were kept during the colder months. Today, an orangerie could range from an observatory, to the classical space for fruit trees in winter or any other greenhouse purpose.
They were a classical symbol of wealth, as glass was an expensive material.

HOT HOUSE

Strictly speaking a greenhouse is only heated by the sun, while a hot (sometimes, warm house, depending on the temperatures) house is additionally heated by heat source.
The two terms, greenhouse and hot house are used interchangeably today, even by professionals.

CLOTHING THE INVISIBLE


ströscch

UNFOLDING THE PROJECT OF A GREEN NODE IN AN INDUSTRIAL LANDSCAPE

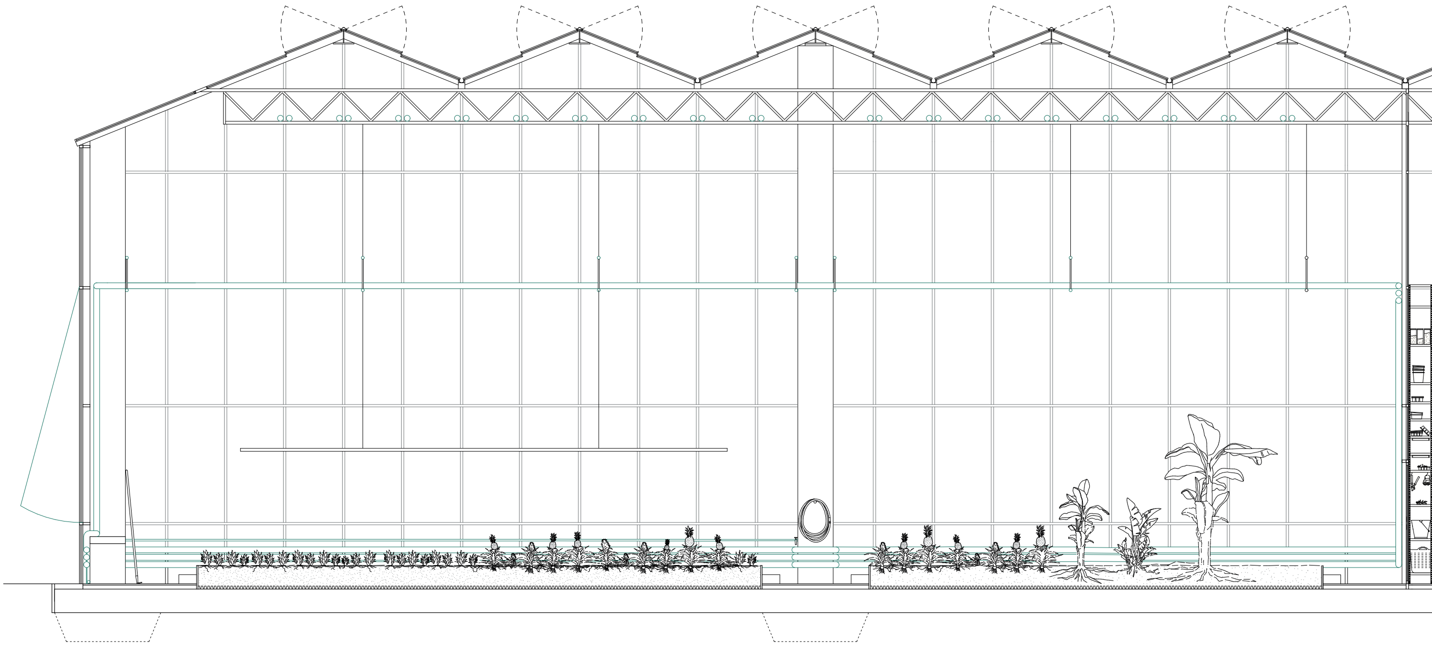
Urban Context
The findings of the research surrounding the material of glass conclude in the establishment of a particular project that is connected to the secondary production line of glass in Switzerland. The idea to make the heat somehow visible, while still connecting it to the agricultural landscape of Switzerland resolved in the setting of a greenhouse complex, that offer the availability of different vegetables and fruits, as well as offer services to the neighbourhood and urban context. The project is embedded in a tringle of three Swiss cities, Gossau, St. Gallen and Herisau. In an immediate context the project connects to an industrial zone and is directly linked to the Glas Trösch facility. As mentioned, in concept, the greenhouse complex is operating on a district heating system, that is connected to the heat exhausted by the ovens.

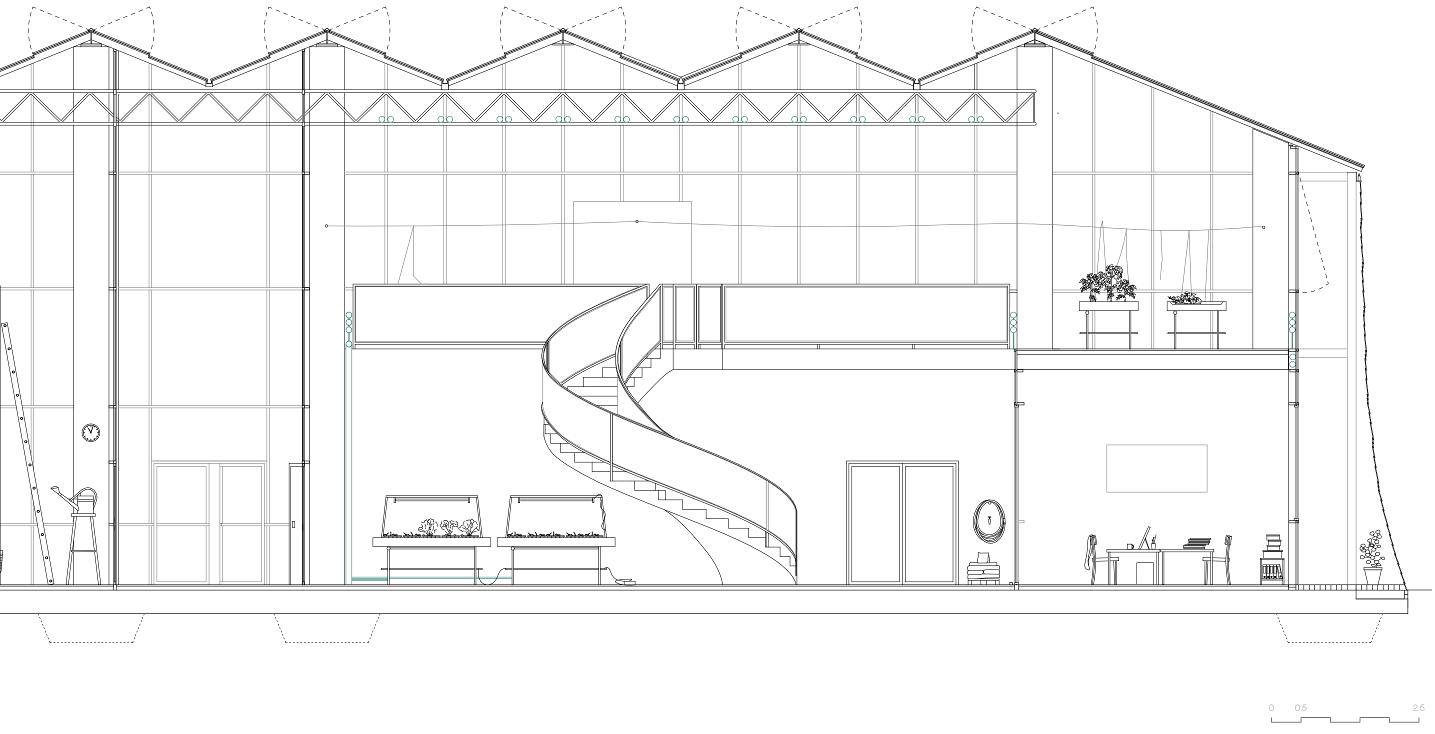
The site sits not only in the industrial landscape, it also connects into a leisure network of national bike routes (in red) and national hiking paths (in yellow). The greenhouse project is easily accessible by public and private transport.


Engelburg
Abtwil

Formal Considerations

In intensive greenhouse cultivation the form of Venlo Greenhouses has become the standard, due to their high light transmission rate. Light is the most important production factor for the growth of plants, as 1% more transmitted light equals to 1% more production mass. The Venlo construction allows tall building height, which is important for a stable climate in the greenhouses which ensure the health of the cultures. The heights of the different building parts differ in terms of their function.





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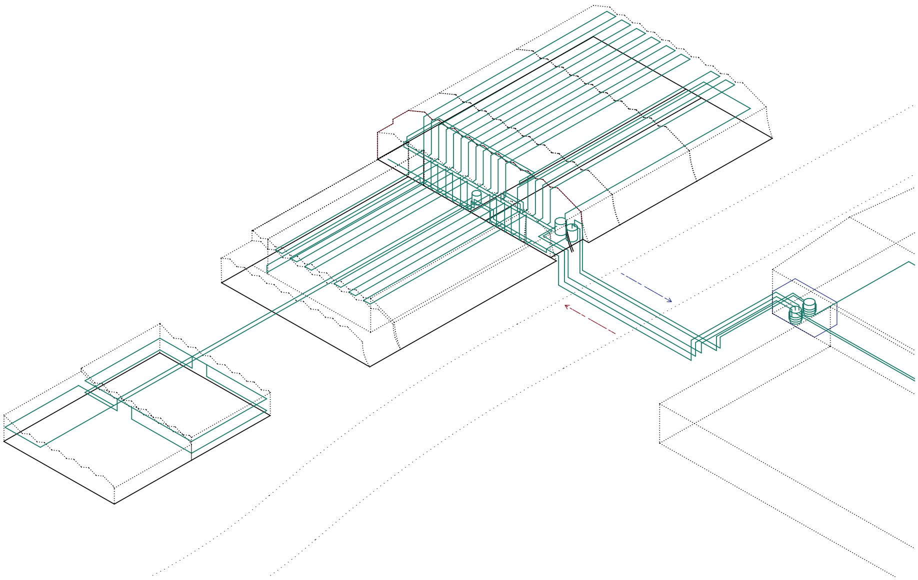
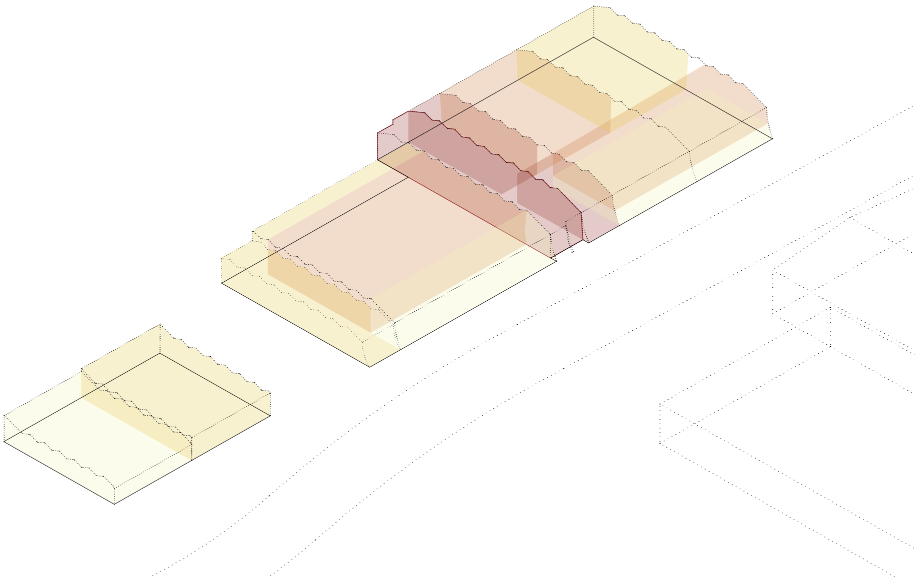




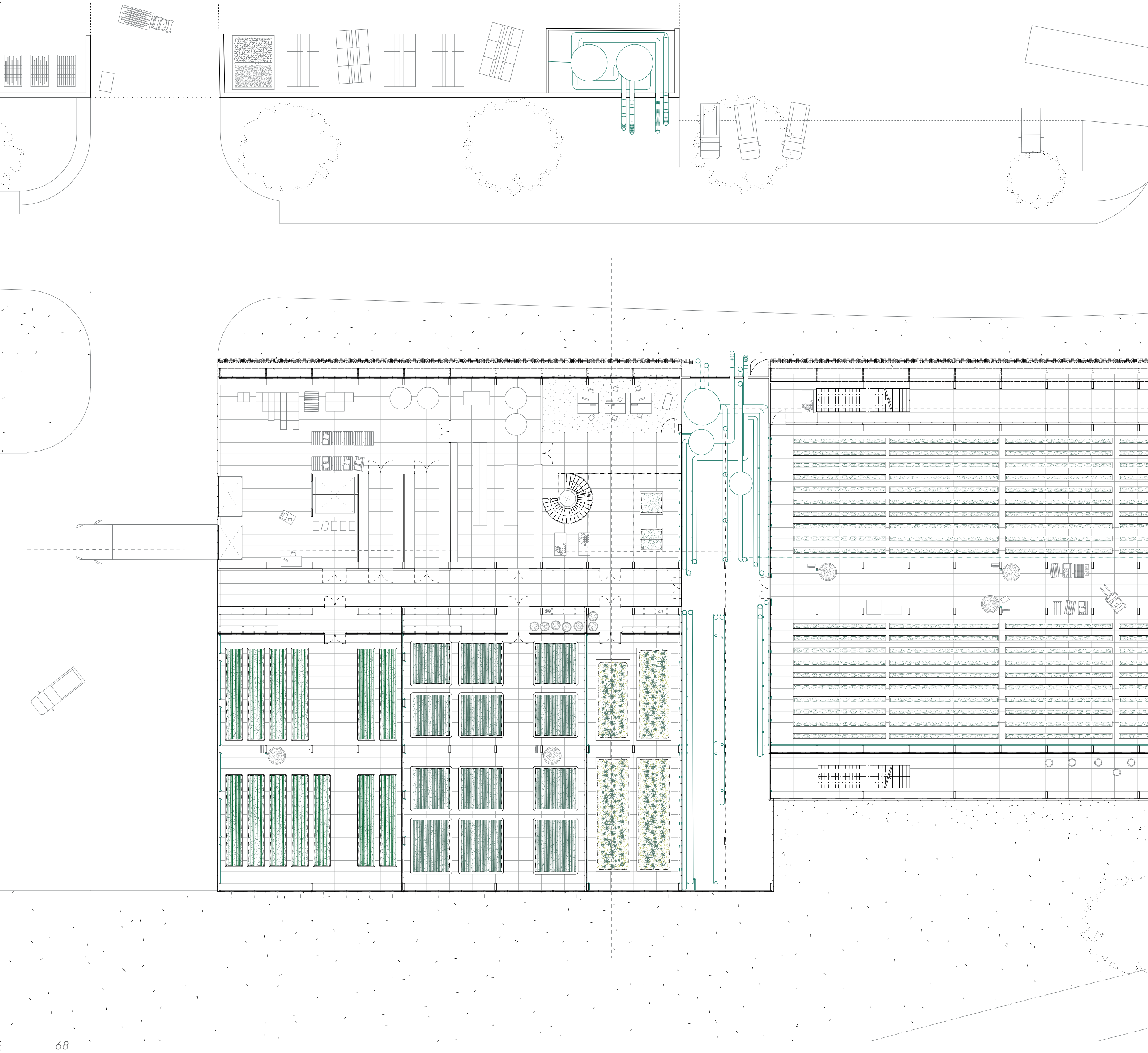
Spatial allocation and organisation

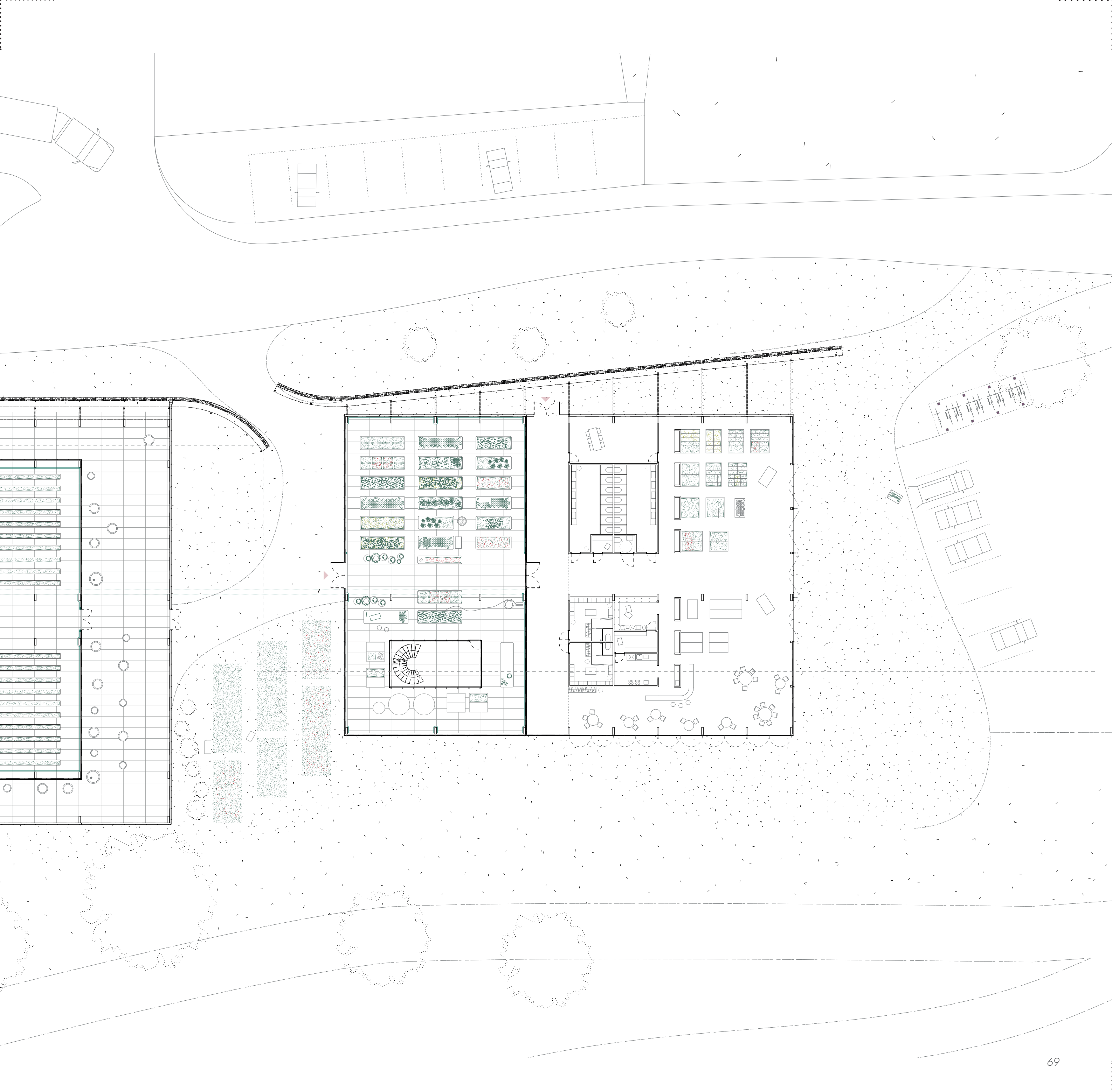
The building is organised on a grid, whereas the heating central provides the spine for the building. Along an axis, the heating pipes build up the framework. In relation to the heating system and the growing distance from the heating central, the spaces are organised depending on their heating demands.

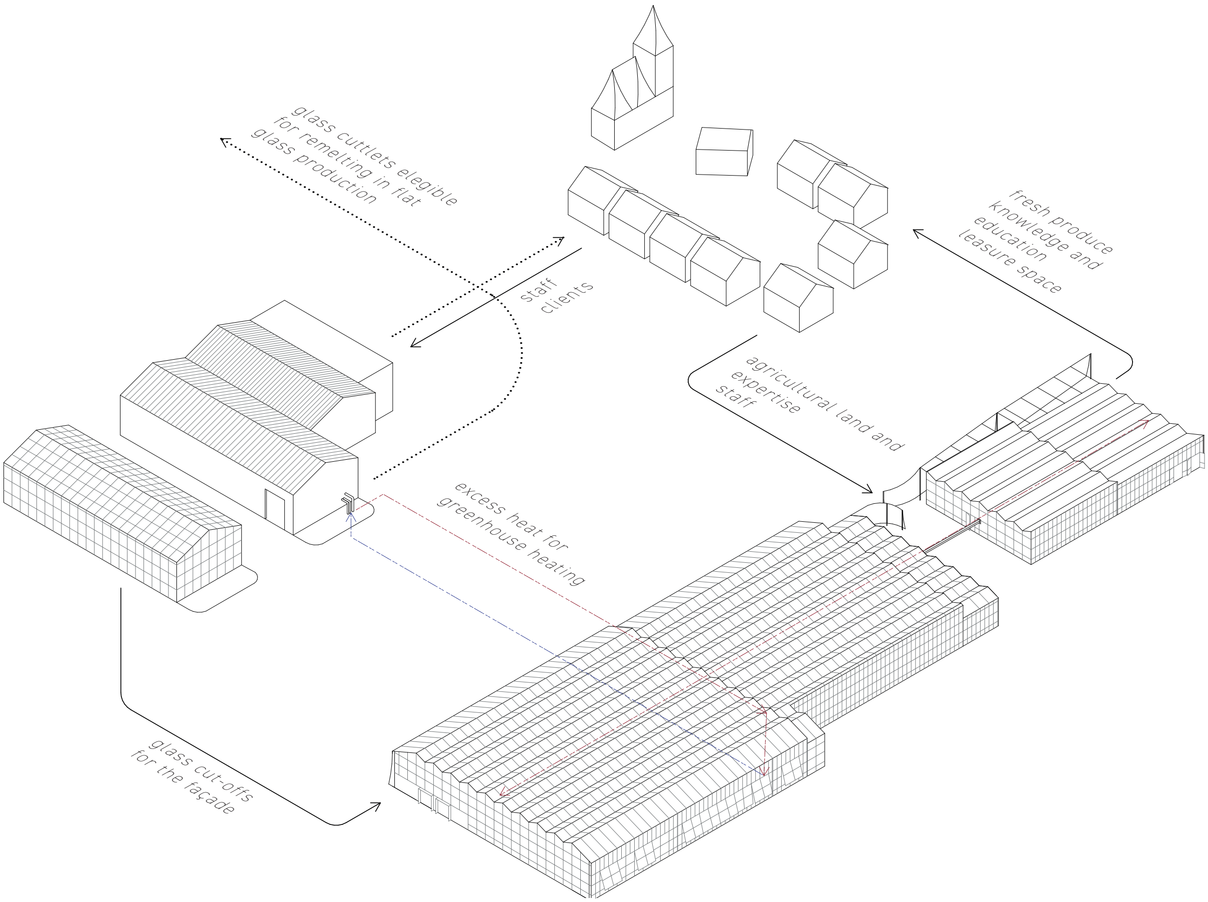
Estimated heating Volume

Based on statements from the two visits, I assume the heat excess to the glass processing is double than they need to heat the indoor spaces to a comfortable temperature, which is between 20-24C°. The total volume to be heated I estimate around 360’000 m3, which are large volumes, one of them resembling a glass house architecture. The excess heat can then be easily used to heat the greenhouses on the opposite street, which a smaller footprint.
A similar principle has already been proven in Wittenberg, Germany, where a fertilizer factory heat 7 ha of greenhouses with its excess heat, or in Belgium, where the META Project is heated by the heat of waste incinerator plant.

To further base the size of the greenhouses placed opposite of the glass processing factory, it is worth looking into the primary production line of flat glass. To enable the glass to cool down evenly and slowly to ensure the optimal structure, the line after the tin bath must be additionally heated, up to 680 °C. This resembles the temperature that is needed in the processing facility for the creation of tempered security glass. Since I can do only an estimation on how much security glass is produced in a day, I stayed quite conservative with the numbers.
In the table for the float glass line, there is a heat loss about 1200 MJ per ton of glass. One standardized sheet of glass (321cm x 600cm) weights at a thickness of 4mm equals a weight of 190 kg – I assume there are easily 5 of such glass panels converted into the final tempered sheets, due the largeness of the factory. Assuming the heat loss would be slightly less in the factories, as the ovens are not quite as hot and reach between 600 -650°C. We equal that in a heat loss of 36 GJ that is resemblant about which is equal to 20 ha of heating power. The size of the of zone next to the plant equals in around 1 ha, which proves that there is more than enough heating to be used for the greenhouses, even so to host plants from warmer climates.
Considering all this, it is still leaving open a certain amount of heat that remains unused. Large distribution centres of retailers like Coop and Migros are in close vicinity and could profit from the heating as well, maybe even setting up their own greenhouses to produce more locally sourced fruits and vegetables. This would eliminate other costs of transportation and logistics. As already mentioned, the factory of Glas Trösch is surrounded by vast fields of agricultural land. The establishment of private relationships to the local farmers and providing them a framework with the case study, the area of planting could be extended to additional fields, resulting in benefits for the population of Switzerland as well as the farmer who owns the land.







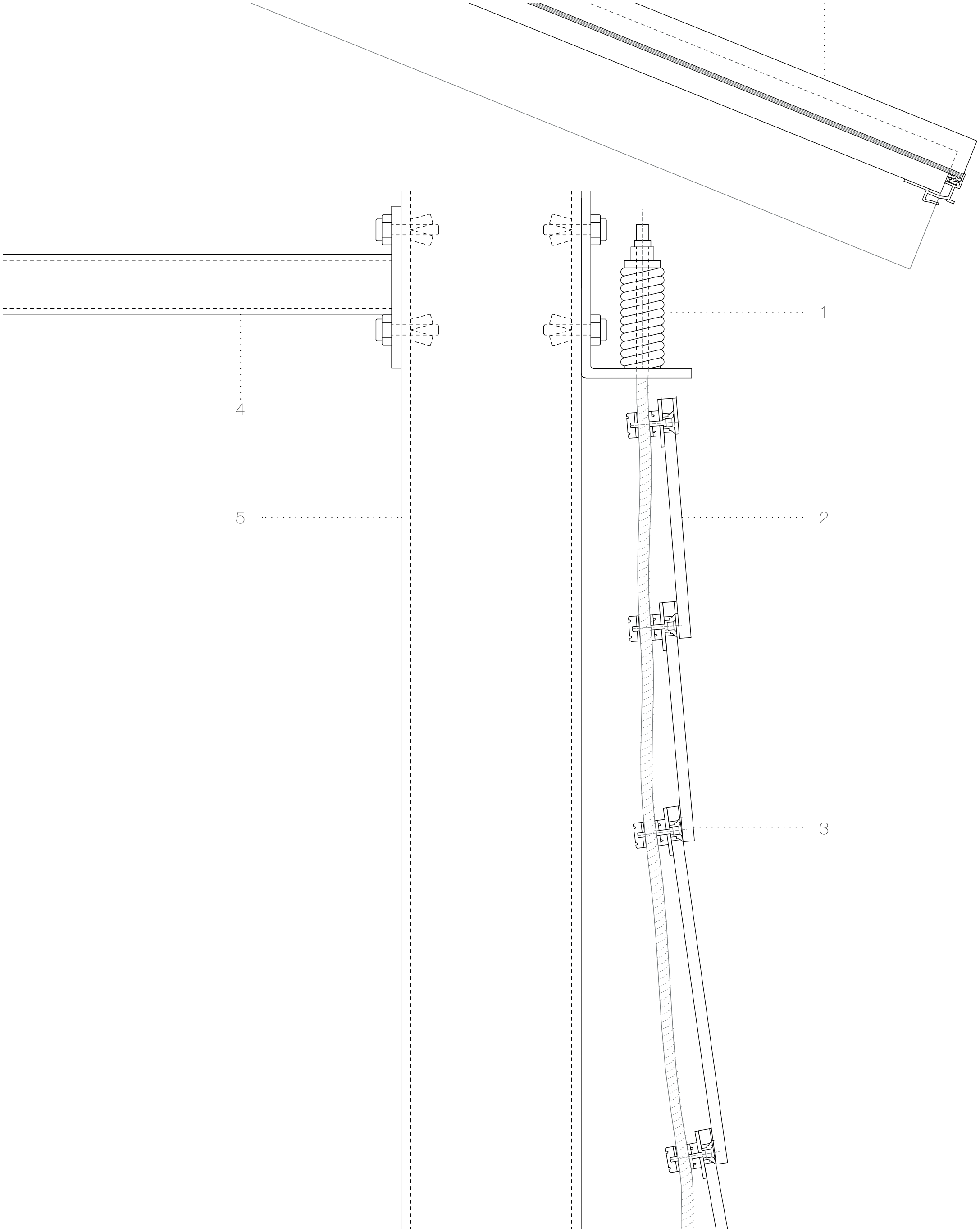
glass cuttlets elegible
for remelting in flat
glass production
staff
clients
fresh produce
knowledge and
education
leasure space
agricultural land and
expertise
staff
excess heat for
greenhouse heating
glass cut-offs
for the façade

Alternative Scenario for the Recycling Cycle

The second focus of the project is aiming to change common practices, questioning the need for absolute perfection in glass. In the second half of the 19th century, it was common practice to divide the glass into different classes, defined by the quality of the transparency. Usually, the lowest class, called ‘Gartenblankglas’ was used for building greenhouses. Such practice could be adopted again easily, as well as optimizing cutting practices in the factories. (Here cutting graphics)
By urging the manufacturers to reuse the smaller scale cutoffs and minimizing the cut offs by optimization of space on the standardized sheets, less material will need to be brought back to the melting factory, downcycled or even end up on a landfill.
In the context of Switzerland, it makes sense to look at this in the scope of larger logistic cycles, as most of the material would stay in the country and be used locally.
The project is picking the aspect of the imperfections of glass and smaller scale piece up in two ways.

1. On the North Façade of the building, the smaller cut-off pieces are creating a curtain like cloth, hanging from the structure of the greenhouse. This creates a kaleidoscopic effect on the visitor halls and breaks up the rigidness of the flat glass panes into a fabric like structure.
2. The technique of the hanging cloth is applied on the smaller scale, modular interventions and can be adapted to current situations. Small scale decorative windows, or lower-class glass sheets for the use of greenhouses.

The smaller glass panels provoking a more textile like manner is a reference to traditional greenhouse and palm houses, such as Paxton’s or Loudon’s Greenhouses in Great Britain. The glass becomes here a skin, an ornament, rather as something that is not perceived at all.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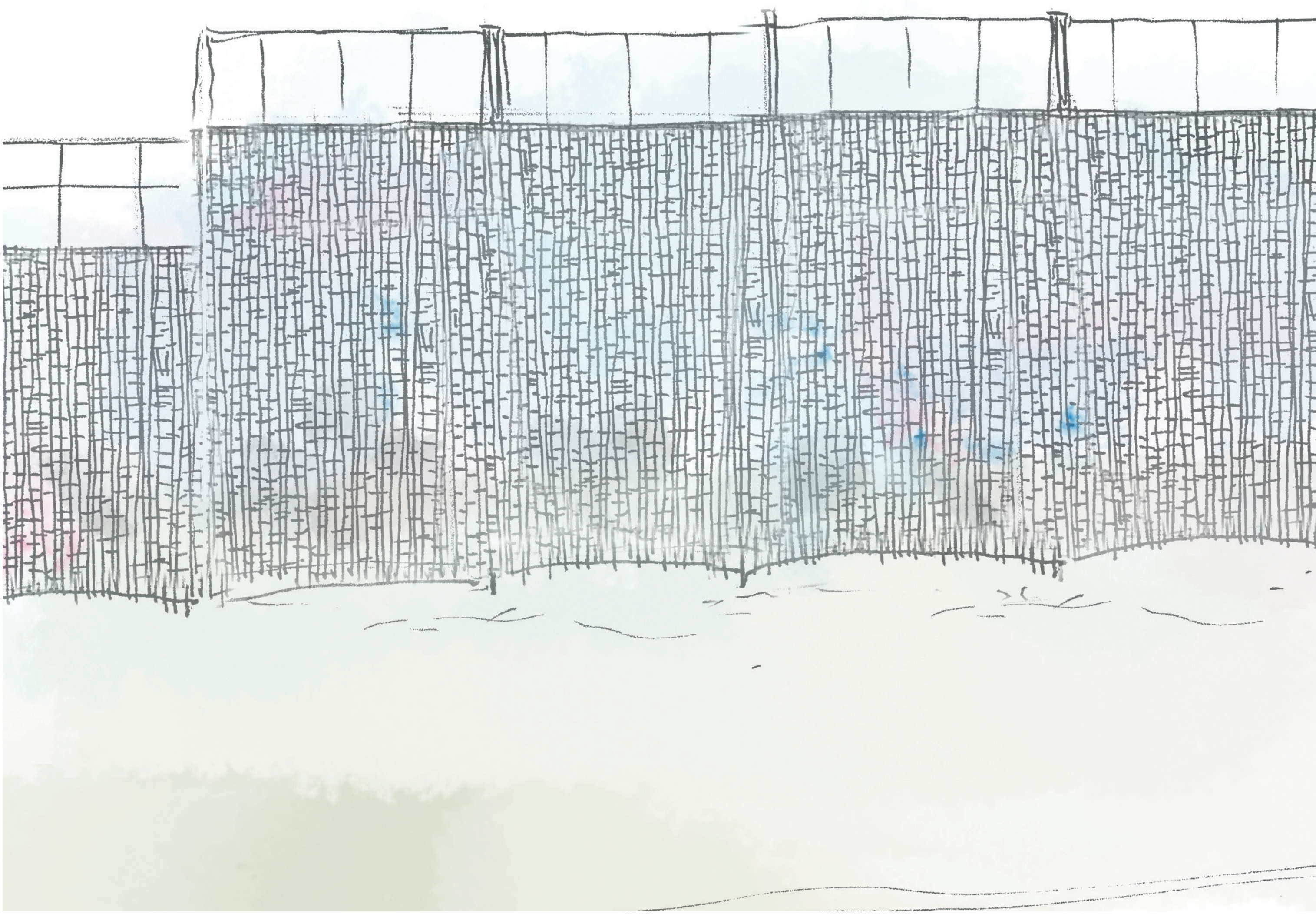
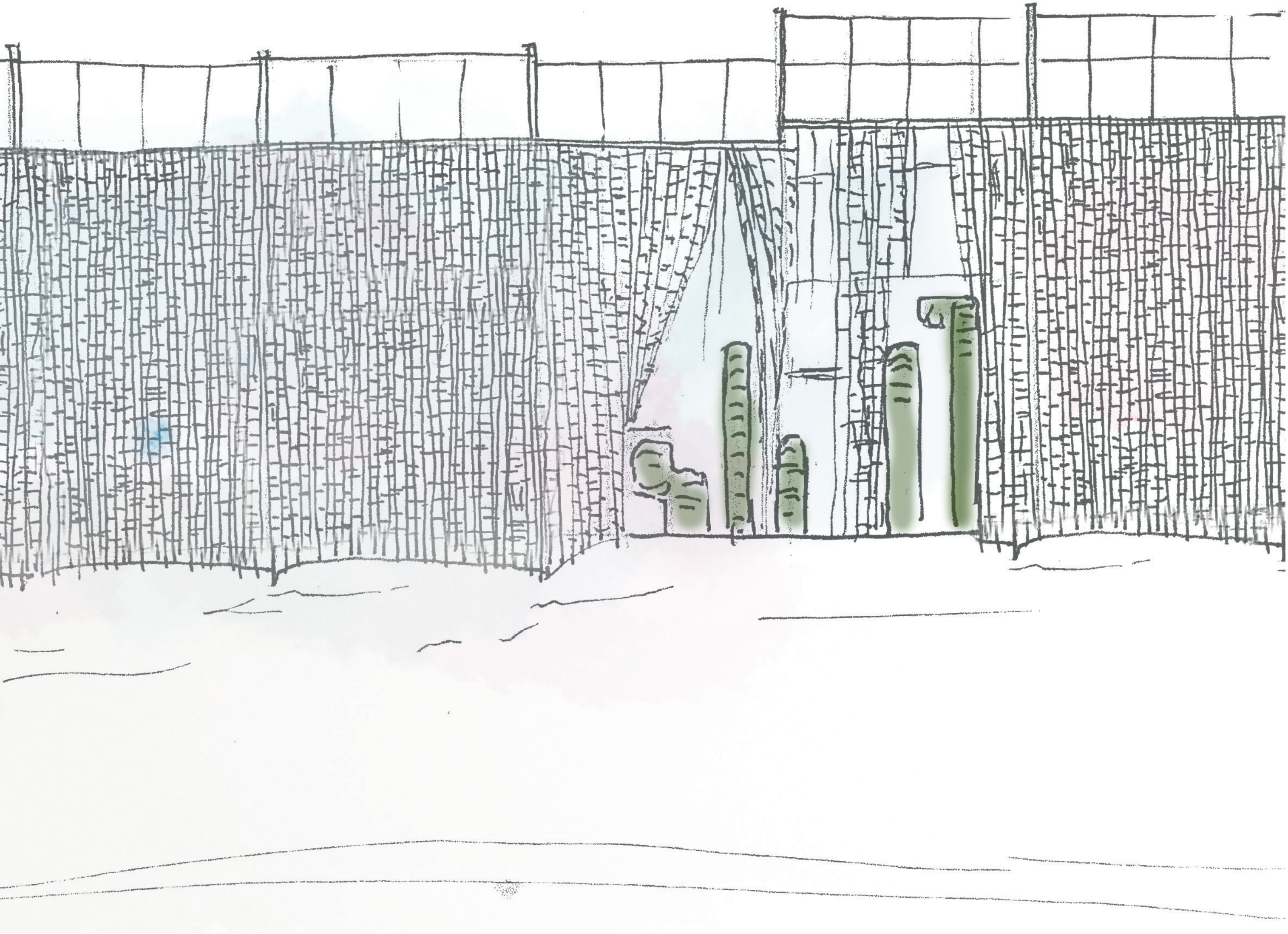
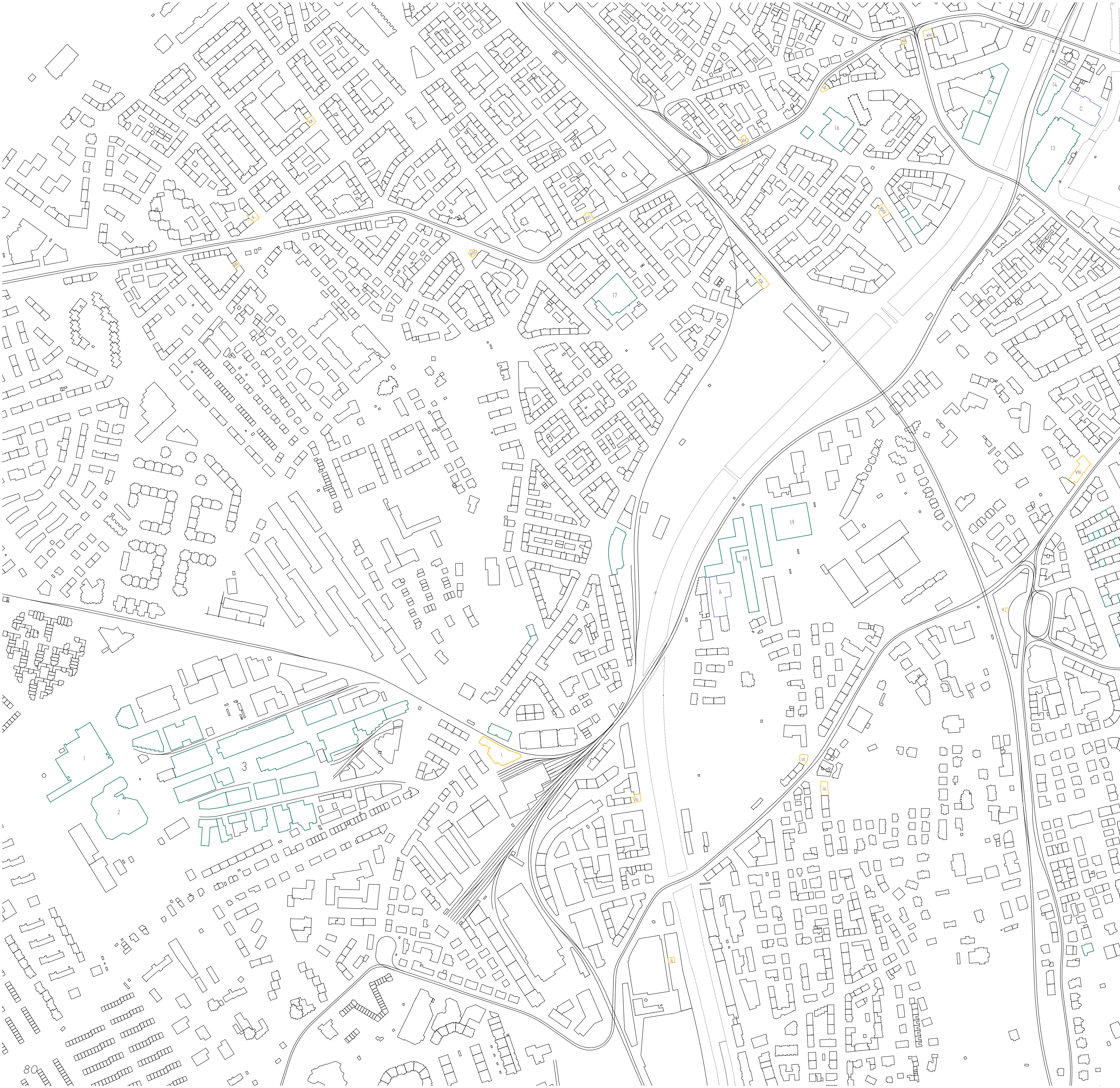




UNVEILING TRANSPARENCIES: MAKING THE HEAT VISIBLE IN THE CITY

The city of Zurich is already developing multiple new strategies on working with excess heat on the larger scale – Heat from the waste incinerator plant in Oerlikon, the wastewater treatment plant in Altstetten or heat out of the groundwater and the lake of Zurich is already being offered in certain districts of the city as a heating alternative.
The energy strategies of the city are always open to discuss alternative sources for smaller, local heating networks. One waste heat source that is growing ever more in numbers, is the warm air of server rooms. This can be considered as well on different scales: an architectural office operating their own server, which needs to be additionally cooled, often through ventilators, which only move the heat to another space.
Internal server stations of larger companies occupying whole floors, emitting the heat to the outside space as well. And lastly, the development of several cloud server stations in and around Zurich lead to the discussion on how to use the excess heat emitted by the super computers. The companies are often in dialogue with local authorities to search for solutions that also benefits the local communities. In the city itself, the data center of Swisscom at Herdernstrasse (image of Herdernstrasse) is embedded into a district heating system and provides heating for homes in the district of Altstetten. The 'Energiezentrale' visible when traveling by train to Zurich, acts as the central node in this scheme. Today, the heat pumps convert 14 Mio. Kwh/a of waste heat from the data centers and the wastewater treatment plant into useable residual heat. With these number, we can assume this covers at least the heating demand of 1000 households



URBAN HEAT SOURCES

COMPANIES

1. Swisscom Schweiz Binz
2. Swiss Life Insurance
3. Office District Binz; Home to numerous Architectural Offices of various sizes
4. Crédit Suisse Head Quarters Albisgüetli
5. Hotelfachschule Belvoirpark
6. Swiss Re Next Mythenquai
7. Zurich Insurances Mythenquai
8. Swiss Life / Rentenanstalt
9. Office / Bank District General-Guisan / Stockerstrasse Location of several Private Banks, Lawyer Offices and other offices (such as Software enterprises, larger companies, Consulates etc.) presumed to operate on an internal server, which would produce excess heat
10. Paradeplatz, Crédit Suisse, UBS Headquarter offices
11. Swiss National Bank
12. Google Bärengasse
13. Education First Headquarters in Alte Börse
14. EWZ Unterwerk Selnau
15. TX Group
16. Stadt Zürich Verwaltungszentrum Werd
17. Orell Füssli Verteilerzentrum / Druckerei
18. Google Hürlimann Areal
19. Bär und Karrer Anwälte / Private Equity Firm Hürlimann Areal

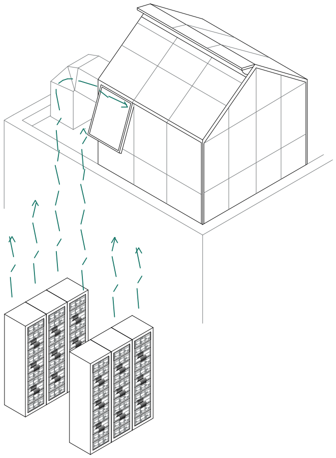
BAKERIES

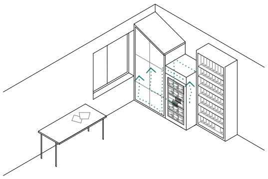
I. Walter Buchmann Bäckerei Fabrik Binz
ii. Confiseur Backmann Sihlcity / Stockerstrasse
iii. Poushe Strudel Waffenplatz
Iv. Bäckerei Café Latte Waffenplatz
v. Jung Bäckerei Enge / Schanzengraben
vi. Walter Buchmann Wiedikon / Rennweg
vii. Bäckerei Gold Wiedikon
viii. Juliette Pain d'Amour Tunnelstrasse
ix. Mosers Backparadies Bleicherweg / Sihlporte
x. Kleiner Bäckerei Stockerstrasse / Goldbrunnenplatz
xi. John Baker Bahnhofstrasse
xii. St. Jakob Beck Münsterhof / Stauffacher
xiii. Confiserie Honold Rennweg
xiv. Bäckerei Hug Stauffacher / Schmiede Wiedikon
xv. Collective Backery Bahnhof Wiedikon
xvii. Konditorei Brändli Schmiede Wiedikon
xviii. Mungg's Brotbäckerei Hallwylplatz
xix. Ma'adan Bäckerei Sihlhölzli
xx. Vuaillat Bäckerei und Konditorei Ämtlerstrasse
xxi. Holzofenbäckerei Vier Linden

BATHS

A, Hürlimann Areal Bad und Spa
B. Fitnesspark Stockerhof
C. Stadtschwimmbad City

This is a selection of sectors of which are present in the urban fabric of the district Enge and Wiedikon. It is exemplary for the city of Zurich, not including heavy industry, or incinerator plants.

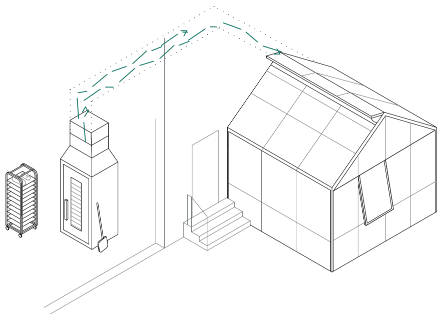




Internal Server Heat

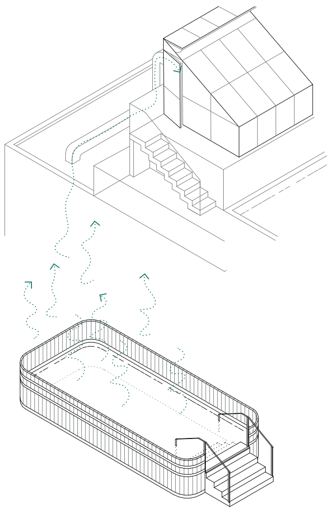
While considering residual heating, larger companies could make use as well of the waste heat of internal servers or of passive heat gains. With digitalisation taking over every aspect of our lifes, companies are relying for their internal network and the local storage of data on servers.

Where there are servers, there is heat: in similar concepts as the greenhouse, a local cooling system could carry the heat to a greenhouse integrated or annexed to the building.



Process heat of bakeries

The theme of running ofens is encountered in urban settings. Bakeries often operate all year around for most of the week, if not all week and can be considered a heating source for a local heating network (as the city of Zurich suggests this as a solution), The process heat to bake bread and therefore supply the neighbourhood with grocieries and the basic food of humanity could enable a small greenhouse adjoing to also grow some vegetables, while creating a small green escape.



The ritual of bathing

Offering spaces of reflection, botanical gardens and bathing facilities are alike. These spaces could be thought of together, in extension of each other and their dependence of some sorts. The Hürliareal not only hosts a large complex of Google offices with heat from their servers, but also provides a home to one of the most known bathing spaces in the city, the Hürlimann bath. Thermal baths are a well visited place, as it offers relaxation for the stressed city mind.The addition of a house of plants, adds another layer to the thermal bath experience.

APPENDIX

Notes and Tables / Sources

Abbildung 21: Sankey-Diagramm in der Flachglasbranche

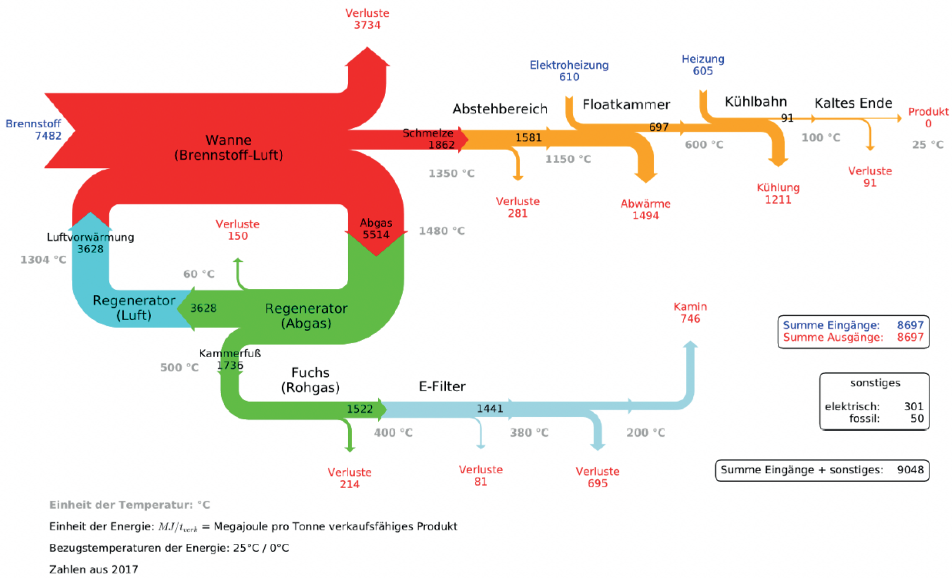


Abbildung 23: Schematische Darstellung der Abwärmeströme in der Formgebung der Flachglasindustrie

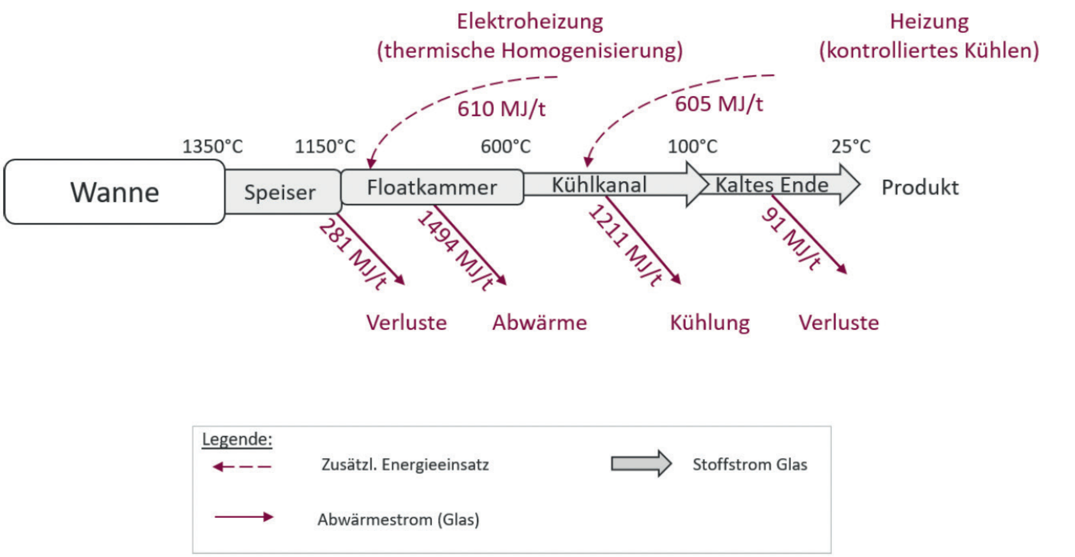


Tabelle 6: Abwärmeströme im Herstellungsprozess von Flachglas

Prozessschritt		Stoff-strom	Genutzte Abwärme [MJ/t]	Gefasste Abwärme [MJ/t]	Diffuse Abwärme [MJ/t]	Eingangs- und Ausgangstem-peratur [°C]	Beschreibung der Abwärme
Schmelze	Schmelzwan-nenverluste		-	448	3.286	Max. Gewöl-betemperatur ca. 1.600 °C	Wannenver-luste
	Wärmerückge-winnung (Rege-nerator/ Reku-perator)	Abgas	3.628	-	150	1.480 – 500	Wärmerück-gewinnung durch Regene-rator, Verluste an Regenerator
Formge-bung & Kühlung	Abstehbereich	Glas	-	-	281	1.350 – 1.150	Verluste durch Abkühlung des Produktes
	Formgebung (Floatkammer)		-	-	1.494	1150 – 600	Floatkammer Abwärme, incl. Elektro-heizung zur thermischen Homogenisie-rung
	Kühlbahn		-	-	1.211	600 – 100	Kontrolliertes Abkühlen
	Kaltes Ende		-	-	90	100 – 25	Abkühlung des Produktes
Abgasrei-nigung	Fuchs (Rohgas)	Abgas	-	214		500 – 400	Reaktionsakti-vität der Ab-sorptionsmit-tel im E-Filter bei 400 °C er-halten
	E-Filter		-		81	400 – 380	Diffuse Wär-meverlust am E-Filter
	E-Filter bis Ka-min		-	695		380 – 200	Säuretau-punkt von 200 °C darf nicht unter-schritten wer-den
	Kamin			746		200	Technologisch nicht nutzbare Abwärme
Summe			**3.628**	**1.357**	**6.594**		

4.3 Quarzsand

Mit Abstand größtes Abbauunternehmen von Quarzsand in Deutschland und mit deutschlandweit rund 1.200 Mitarbeitern ist die 1884 gegründete Quarzwerke GmbH (Homepage: www.quarzwerke.com) mit Hauptsitz in Frechen. In Deutschland fördert das Unternehmen aus sechs verschiedenen Quarzsandlagerstätten:

Frechen, westlich von Köln. Hier lagern 25 Mio. Jahre alte, fein- und mittelkörnige Strandsande von durchschnittlich 48 m, maximal sogar 70 m Mächtigkeit und hoher Reinheit (> 99 % SiO_2). Mit geschätzten Restvorräten von rund 100 Mio. t handelt es sich um eine der bedeutendsten Quarzsandlagerstätten Deutschlands. Bereits in römischer Zeit wurde hier Quarzsand für die Glasherstellung gewonnen und 1884 begann der industrielle Abbau. Heute, gut 130 Jahre später, wird der Quarzsand bei Frechen in einem großen Tagebau mit Schaufelradbaggern abgebaut und in einem benachbarten Quarzsand- und -mahlwerk zu jährlich bis zu 800.000 t hochwertigen Quarzsanden und -mehlen für die Baustoff-, Glas-, Gießerei-, Keramik-, Feuerfest- und chemische Industrie aufbereitet.

Abbaustellen von als Industriemineral genutztem Quarzsand in Deutschland, Karte: BGR.

<table>
<tr><th>Kultur</th><th>Produktionsart</th><th colspan="2">Jan.</th><th colspan="2">Feb.</th><th colspan="2">März</th><th colspan="2">April</th><th colspan="2">Mai</th><th colspan="2">Juni</th><th colspan="2">Juli</th><th colspan="2">Aug.</th><th colspan="2">Sept.</th><th colspan="2">Okt.</th><th colspan="2">Nov.</th><th colspan="2">Dez.</th></tr>
<tr><td rowspan="2">Gemüse</td><td rowspan="2">Hors-sol sehr intensiv</td><td colspan="21">Bsp. Tomaten / 18..20°C</td><td colspan="3">frostfrei</td></tr>
<tr><td colspan="7">Typ nach EN-131: Warmhaus</td><td colspan="8">Max. U-Wert: 2.4 W/m^{2}K</td><td colspan="9">typ. Wärmeverbrauch: 250 kWh/m^2</td></tr>
<tr><td rowspan="2">Gemüse</td><td rowspan="2">Hors-sol/Boden intensiv</td><td colspan="2">Salat</td><td colspan="18">Bsp. Tomaten / 18..20°C</td><td colspan="4">Salat / 5...8°C</td></tr>
<tr><td colspan="7">Typ nach EN-131: Warmhaus</td><td colspan="8">Max. U-Wert: 2.4 W/m^{2}K</td><td colspan="9">typ. Wärmeverbrauch: 200 kWh/m^2</td></tr>
<tr><td rowspan="2">Gemüse</td><td rowspan="2">Bio (Boden)</td><td colspan="4">Salat / 5...8°C</td><td colspan="15">Bsp. Tomaten / 18..20°C</td><td colspan="5">Salat / 5...8°C</td></tr>
<tr><td colspan="7">Typ nach EN-131: Warmhaus</td><td colspan="8">Max. U-Wert: 2.4 (2.1) W/m^{2}K</td><td colspan="9">typ. Wärmeverbrauch: 170 kWh/m^2</td></tr>
<tr><td rowspan="2">Gemüse</td><td rowspan="2">Hors-sol/Boden extensiv</td><td colspan="7">Salat / 5...8°C</td><td colspan="10">Bsp. Gurken / 18..20°C</td><td colspan="7">Salat / 5...8°C</td></tr>
<tr><td colspan="7">Typ nach EN-131: Kalthaus</td><td colspan="8">Max. U-Wert: keine Vorgabe</td><td colspan="9">typ. Wärmeverbrauch: 100 kWh/m^2</td></tr>
<tr><td rowspan="2">Zierpflanzen</td><td rowspan="2">intensive Kulturen</td><td colspan="1"></td><td colspan="8">Bsp. Pelargonien / 10...18°C</td><td colspan="4">Kultur ungeheizt</td><td colspan="10">Bsp. Poinsettien P13 / 15...21°C</td><td colspan="1"></td></tr>
<tr><td colspan="7">Typ nach EN-131: Warmhaus</td><td colspan="8">Max. U-Wert: 2.4 W/m^{2}K</td><td colspan="9">typ. Wärmeverbrauch: 200 kWh/m^2</td></tr>
<tr><td rowspan="2">Zierpflanzen</td><td rowspan="2">extensive Kulturen</td><td colspan="6">Bsp. 1...5°C</td><td colspan="18">max. 1°C</td></tr>
<tr><td colspan="7">Typ nach EN-131: Kalthaus</td><td colspan="8">Max. U-Wert: keine Vorgabe</td><td colspan="9">typ. Wärmeverbrauch: 20 kWh/m^2</td></tr>
<tr><td rowspan="2">Beeren</td><td rowspan="2">intensiv</td><td colspan="10">Himbeeren / 6..13°C</td><td colspan="14">ungeheizt</td></tr>
<tr><td colspan="7">Typ nach EN-131: Warmhaus</td><td colspan="8">Max. U-Wert: 2.4 W/m^{2}K</td><td colspan="9">typ. Wärmeverbrauch: 40 kWh/m^2</td></tr>
<tr><td rowspan="2">Beeren</td><td rowspan="2">extensiv</td><td colspan="6">ungeheizt</td><td colspan="4">Himb. / 6..8°C</td><td colspan="14">ungeheizt</td></tr>
<tr><td colspan="7">Typ nach EN-131: Kalthaus</td><td colspan="8">Max. U-Wert: keine Vorgabe</td><td colspan="9">typ. Wärmeverbrauch: 5 kWh/m^2</td></tr>
</table>

Tabelle 7 Übersicht Energiewerte typische Kulturen und Produktionsmethoden

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