

"Connecting the Maassilo"

Sustainability report

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CIRCULAR ECONOMY

Next to socially and physically connecting the Maassilo, the other main objective to incorporate in my design for adaptive reuse is sustainability. Sustainability is no longer just a bonus for a design, it has become a necessity in order for buildings to be resilient and adaptive to climate change, limited material resources, and to the depletion of fossil fuels. Working with heritage and taking an existing building to fit current needs and new functions is already the first small step in the right direction for a sustainable project, since you are reusing an entire building. Since sustainability has become more and more popular over the last years, many designers and other people in the built environment are now working with a new standard where buildings at least have sufficient insulation to prevent energy loss, and some solar panels to cover a small portion of the electricity use in a building. But instead of merely putting some of these sustainable 'add-ons' on the Maassilo, I want to have an integrated and all-including sustainable design.

The integrated approach I chose is that of the Circular Economy, as designed by the Ellen MacArthur foundation. In this circular system, displayed in figure 1, the streams of organic and inorganic materials are placed in a cascading system that is designed to keep the value of a material as high as possible at all times and to minimize waste. Materials that have been used for process 1, starting on the outer circle of the diagram, and that have lost their value or have turned into waste in this process, return to the system in the next circle to be recycled or reused and act as a highly valuable resource in process 2. The waste or leftover product of process 2 then continues to process 3 and so on. The processes within the system are powered by renewable energy sources to preserve and enhance nature, and either use as limited finite materials as possible or use them as sparingly as possible.

CIRCULAR ECONOMY - an industrial system that is restorative by design

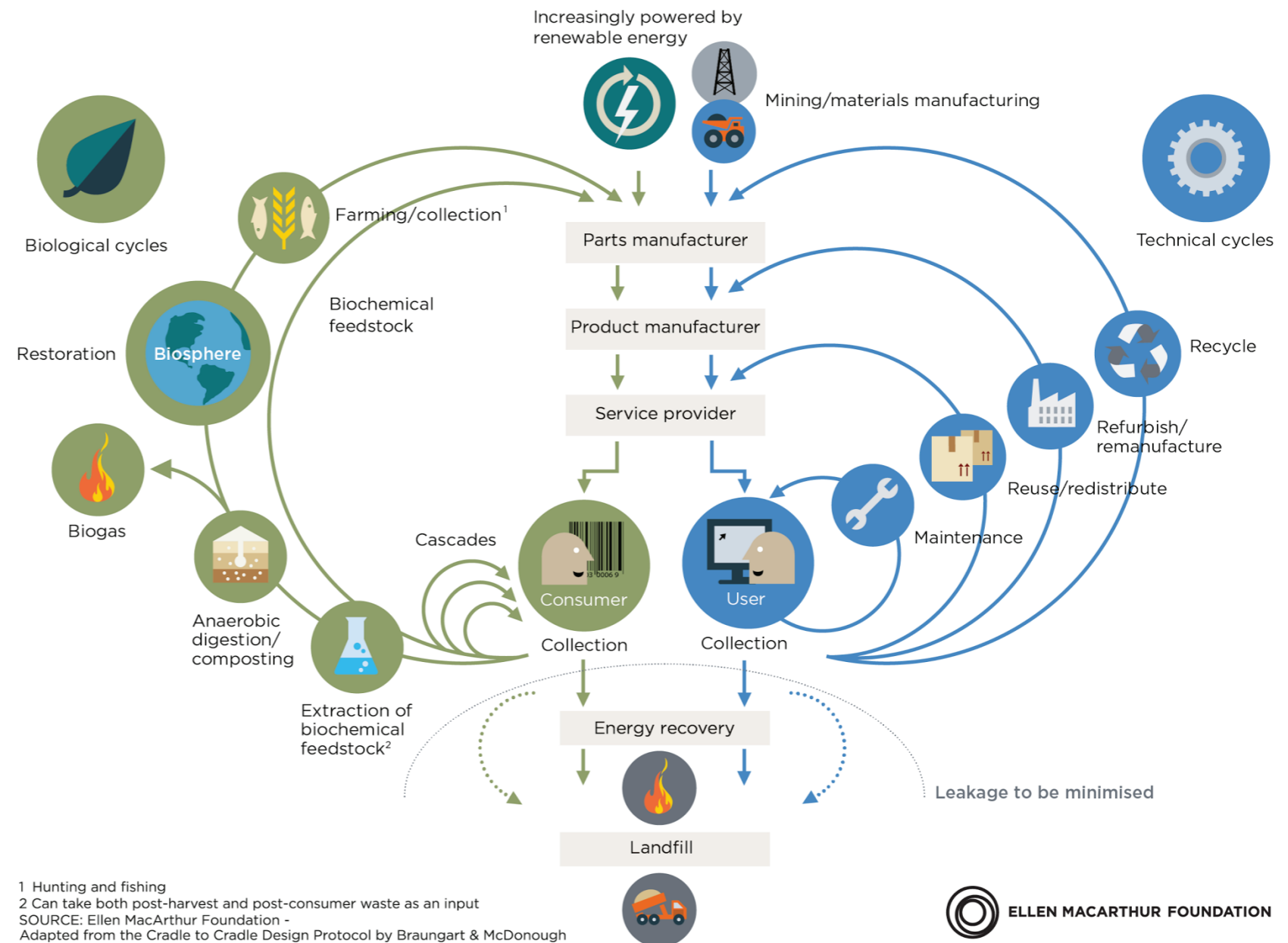


Fig. 1: Circular economy system with cascading streams for organic and inorganic materials as designed by the Ellen MacArthur Foundation.

SUSTAINABILITY CONCEPT IN THE MAASSILO

In my case the circular system is the Maassilo. The building parts that will contain the new functions will all be insulated to reduce the thermal energy need. The streams that I included in my scope for sustainability are shown in figure 2: water, organic materials, building materials (inorganic material) and energy. The central point in my circular economy are the new functions that will take place in phase 1 of the Maassilo: a beer brewery and spent grain bakery. This brewery uses water, organic material (grain, hops, and yeast) and energy in the brewing process. The excess water and generated energy are to be used in the rest of the building.

Inorganic (building) materials is the only category where the material is reused during the construction period of the new design. In the other three categories, the circular systems are working during the use of the building, after construction has finished and as long as the building remains operative.

In the perfect circular economy, all streams are connected, materials are optimally used and reused and there is no waste. I tried generating as much energy and useful products as possible (rainwater, electricity, heat-cold storage in water silos), re-use as much as possible (heat-exchangers, spent-grain bakery) and process waste as much as possible (waterfilters) all on the own site of the Maassilo. With one exception: if I could reuse a material on site but at low efficiency or if the material could be reused elsewhere in Rotterdam at a higher value, then I chose the second option. This in accordance to the EPA scheme shown in figure 3. This doesn't make the Maassilo completely self-sufficient and autonomous but it connects with other parties for a better result, which complies with the concept of 'sharing' in the circular economy, is preferable for the environment, and fits with my design concept of 'Connecting the Maassilo'.

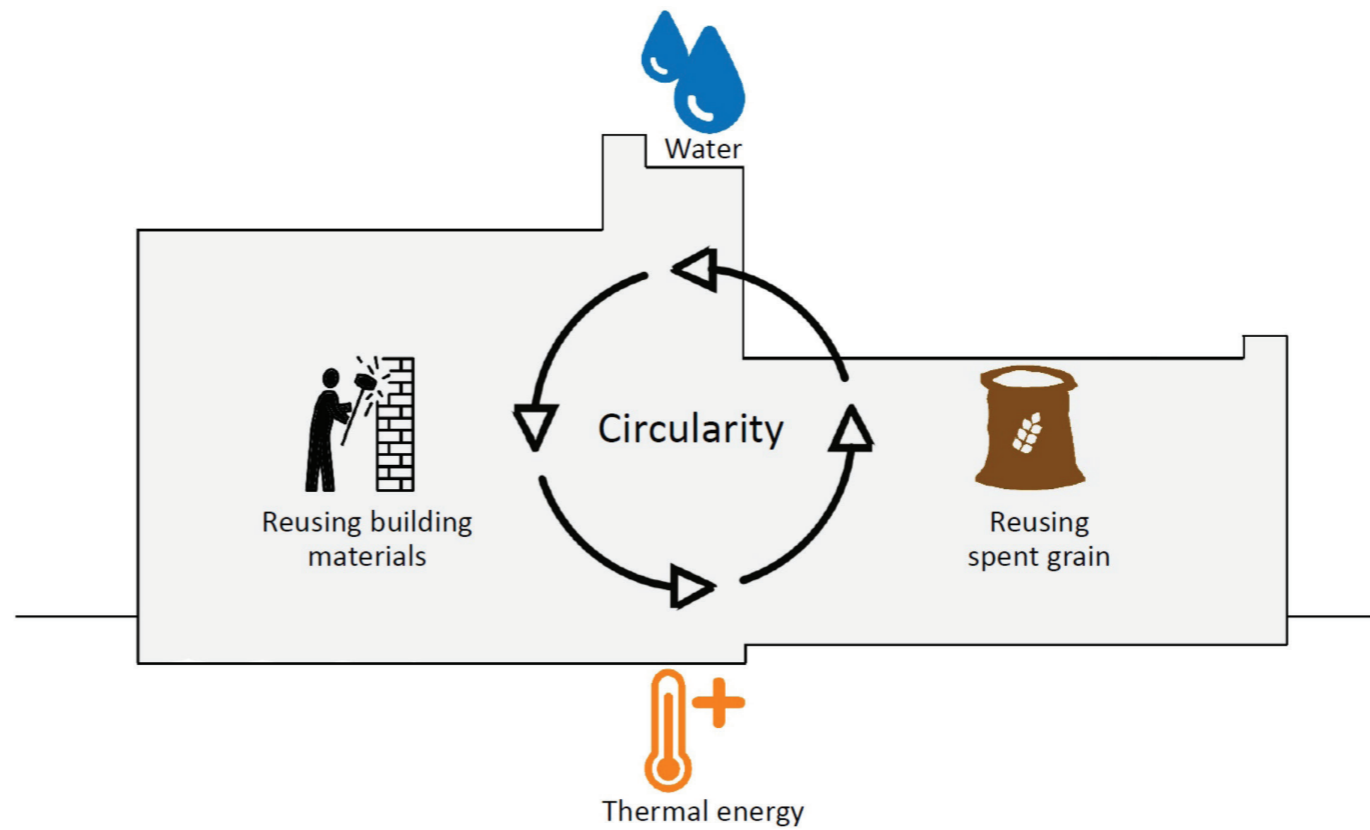


Fig. 2: Overview of four main sustainability topics / systems in the new sustainable design for the Maassilo.

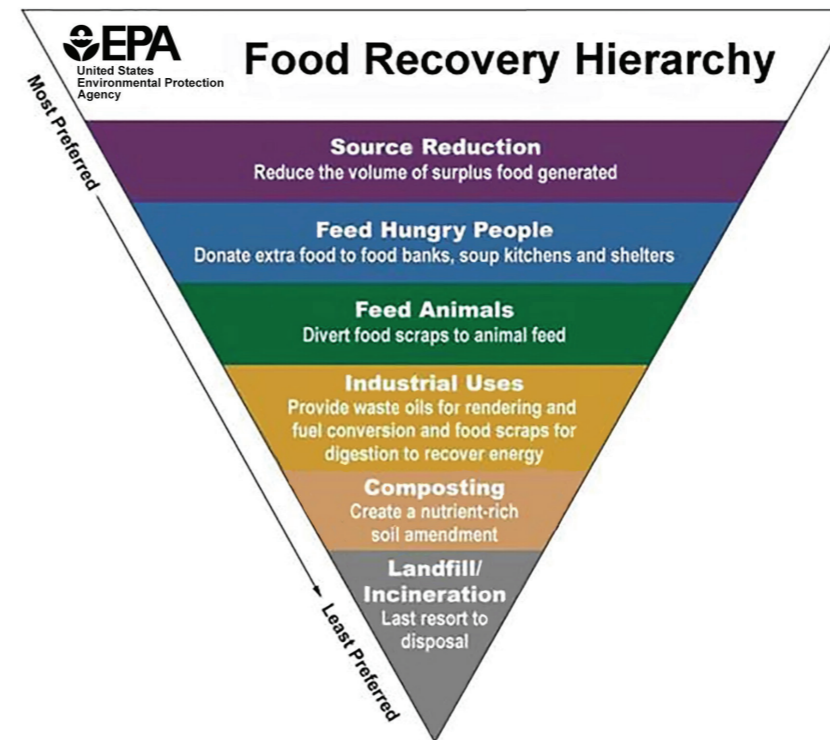


Fig. 3: EPA's Recovery Hierarchy for maximum value reuse of organic materials.

WATER

The watersystem I designed for the Maassilo, shown in figure 4, includes four types of water: filtered water, water from precipitation (rain, hail or snow), grey water (relatively clean wastewater), and black water (dirty wastewater). The filtered water comes from a natural water source nearby or can be regular tap water. Water from precipitation, mostly rainwater, is collected on the green-blue roof that will be constructed on the building, after a secondary structure has been added to the current roof structure in order to support the extra weight. The green-blue roof, displayed in figure 5, consists of a water retention layer with a 'drossel' system by Optigroen, which can regulate the amount of collected rainwater that stays on the roof to water the vegetation above and the amount that is sent through to the rainwater collection silo in phase 3 next to the brewery. The water management by this system ensures that the vegetation always has enough water and that in case of heavy rainfall the roof won't overflow. Above the water retention layer is a substrate layer with an extensive (grasses and herbs) vegetation layer on top.

There are two types of filtration systems: a mechanical filtration system for high quality water that will be used for the production of beer, and a natural filtration system or constructed wetland that filters wastewater up to a point where it can be reused for low-quality use or can be discharged in the Maas. The natural filtration system, which is a horizontal subsurface flow wetland as in figure 6, is located on the quay between the Maassilo and the Maashaven, on the groundfloor. The system consists of multiple basins for different levels of natural filtration. Dirty water enters at the start of the wetland, while relatively clean wastewater joins halfway through. In this subsurface flow wetland, wastewater passes through below the top level of gravel or sand. It is not directly exposed to the atmosphere since the surrounding is a public quay.

The different types of filtered water are stored in various silos in phase 3, next to the brewery. Before reusing the existing grain silos for water storage, they will be covered with an impermeable, water-proof polyurea coating.

During the use-phase, high quality water will be used for high quality purpose, such as beer production or consumption. Whereas lower quality water, like rainwater or filtered greywater, will be used for cleaning or flushing toilets.

After the water has been used, instead of it being collected all together, different quality waste streams are separated so that they can be filtered according to their level of pollution and later reused. Black water first goes to a septic tank where solid elements and additional filter to remove dangerous bacteria. After that, the water will enter the wetland from the start, passing through all different basins in order to come out as clean as filtered grey water.

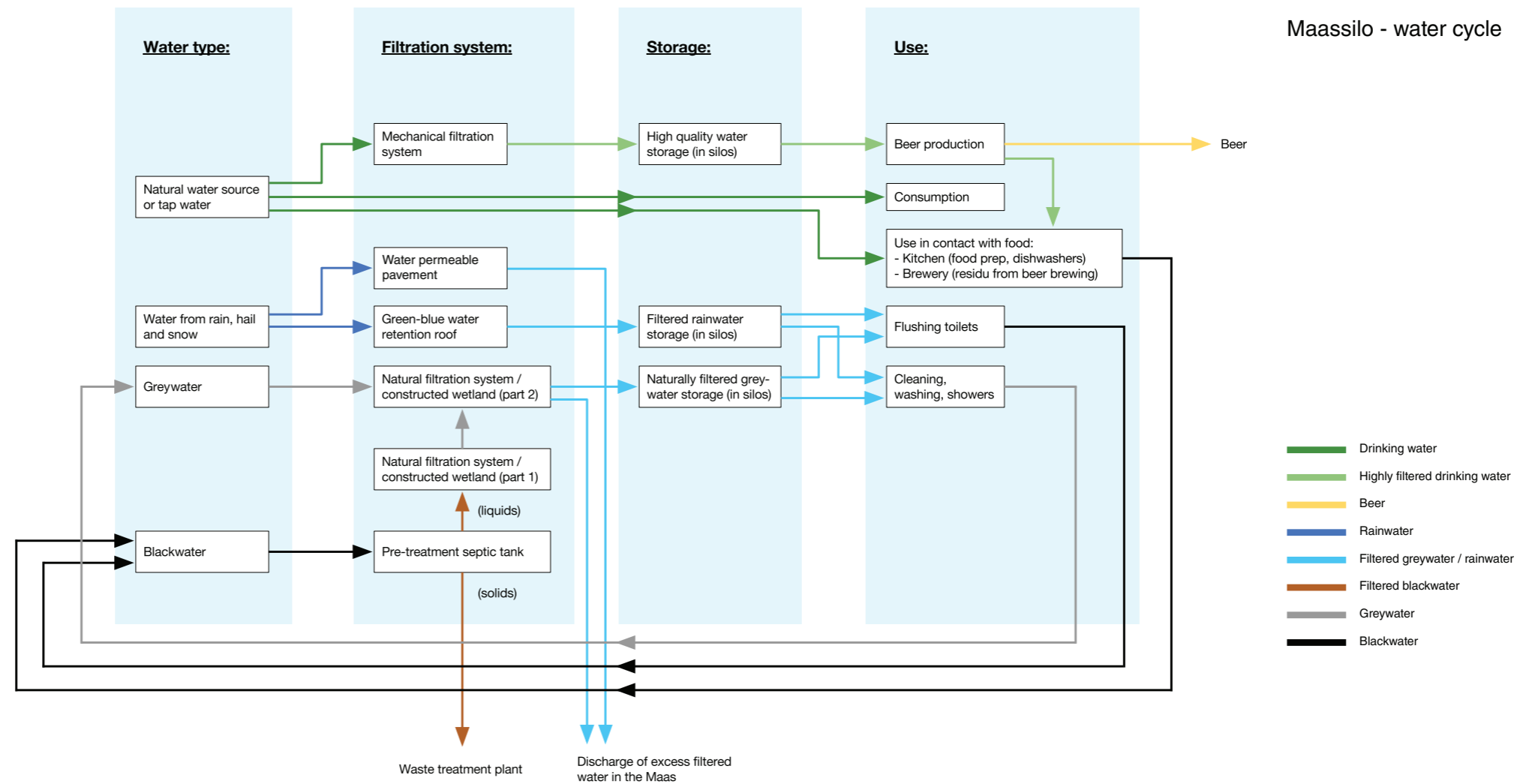


Fig. 4: Circular system for water streams in and around the Maassilo.

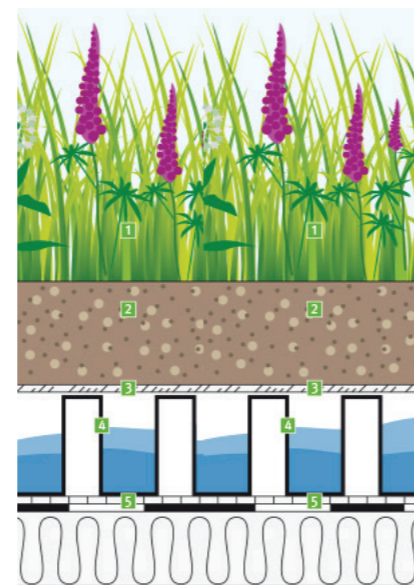


Fig. 5: Green-blue extensive roof with water retention and 'drossel' system.

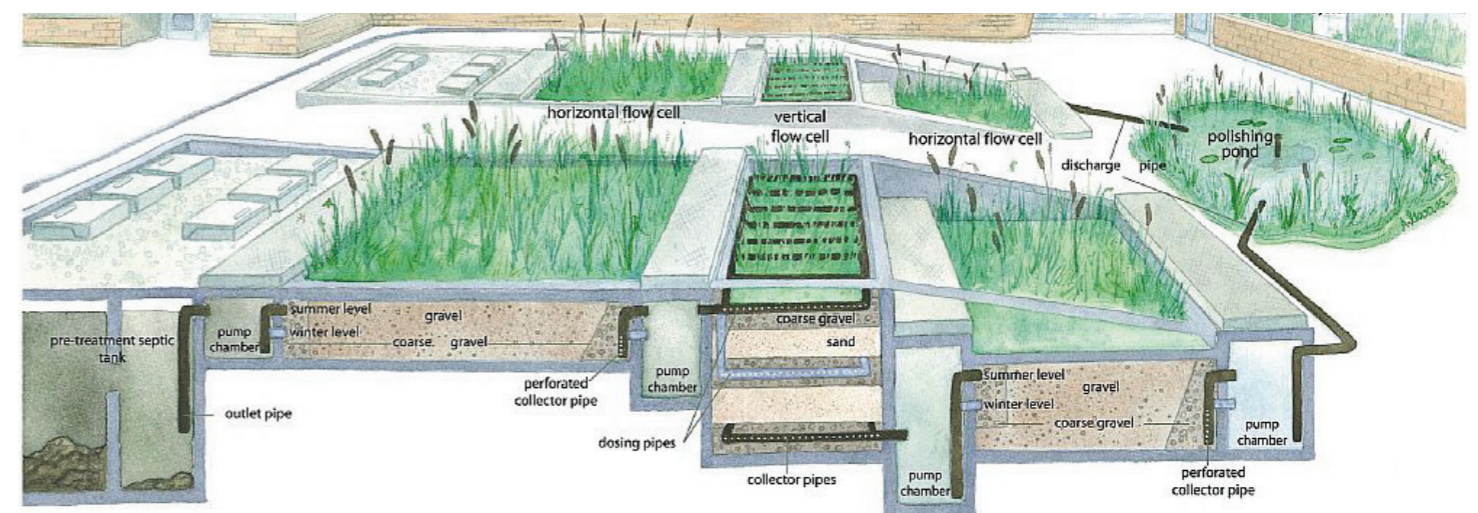


Fig. 6: Example of constructed wetland with multiple basins for different levels of natural filtration.

ORGANIC MATERIAL

The circular system of organic material takes place in the beer brewery, situated in phase 1 and part of phase 3 of the Maassilo. The main ingredients used in the brewing process are water, malt (malted grain), hops and yeast. Water, malt and hops are used and later on removed (turned into 'waste') during the brewing phase. Yeast is added in the fermentation phase and is filtered out afterwards.

When researching the brewing process, which phases it includes and which organic materials it requires, I visited the breweries of Heineken in Amsterdam and Grolsch in Enschede. Although these breweries produce on a larger scale than the Maassilo brewery, especially the Grolsch tour was very helpful and interesting since they do a lot with sustainability and reusing resources.

In the organic circular system, shown in figure 7, the water used in the brewing process ends up as beer. Water used for cleaning the tanks, pipes, bottles and other components will leave the system as grey wastewater where it can be processed according to the circular water system. The largest amount of organic 'waste' is spent grain. This material, after being dried, will be reused in the spent grain bakery underneath the brewery, where there are hundreds of possible recipes to reuse this ingredient, as shown in figure 8. Excess spent grain that is too much to be used in the spent grain bakery could be incinerated to generate energy, but incineration is the least valuable way of reusing organic material. Therefore, following the EPA hierarchy, leftover spent grain and spent hops will be transported to nearby farms to serve as food for livestock, keeping it at maximum value.

Yeast cells are alive during the fermentation process. They multiply and produce daughter cells. This process continues until the yeast has reached the point of fifth generation yeast cells. This fifth generation brewer's yeast will be transported to the pharmaceutical industry for use in shampoo, skin-care products and brewer's yeast tablets, see figure 10.

In the fermentation process, yeast reacts with glucose in the beer mixture and produces alcohol and carbon dioxide. About 5% of this CO₂ stays in the beer, the remaining 95% can be reused in the bottling phase for filling bottles.

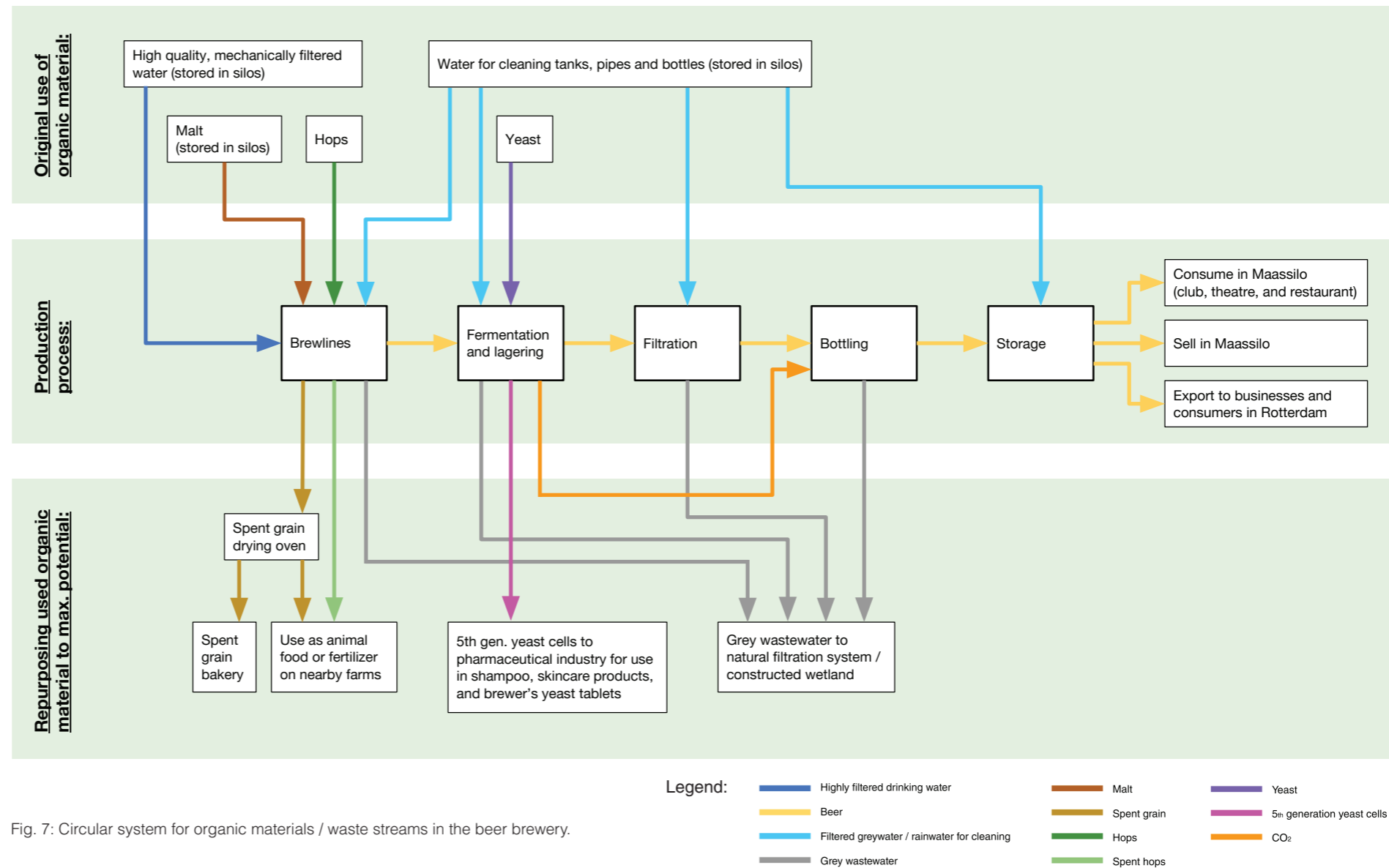


Fig. 7: Circular system for organic materials / waste streams in the beer brewery.

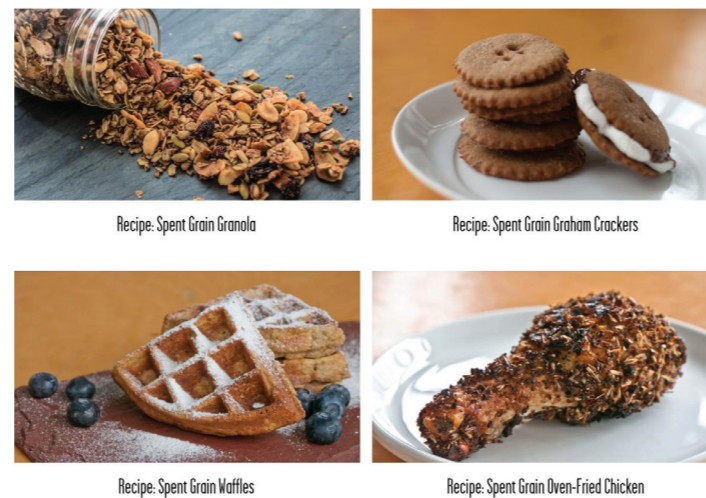


Fig. 8: Examples of various spent grain recipes.



Fig. 9: Spent grain reused as food for livestock.



Fig. 10: Brewer's yeast reused in cosmetic and pharmaceutical products.

INORGANIC MATERIAL

The reuse of inorganic material in the Maassilo is mostly the reuse of silo walls that are cut out the existing structure in order to open up spaces for the new functions. Figure 11 shows the scheme for reuse of this inorganic material.

The best, easiest and highest quality reuse of the silo walls is to directly reuse these concrete slabs as large pavement panels on the new bridge, elevated walkway and pathway across the constructed wetland in my design, as can be seen in the examples in figure 12.

Excess / leftover silo walls will be crushed and the rebar will be taken out. The resulting concrete aggregate will first be used as a substitute for gravel or other coarse aggregates in the subsurface flow wetlands, shown in figure 13.

The remaining concrete aggregate, assuming it consists of at least the required 90% concrete with a density of $\geq 2100 \text{ kg/m}^3$, will be used as a partial substitute for other aggregates in new concrete structures in my design, like in situ concrete floors. In the Netherlands, according to the CUR-Recommendation 112, recycled concrete granulate may replace up to 50% of coars aggregate in new concrete structures without having to adjust the calculations for its strength and characteristics.

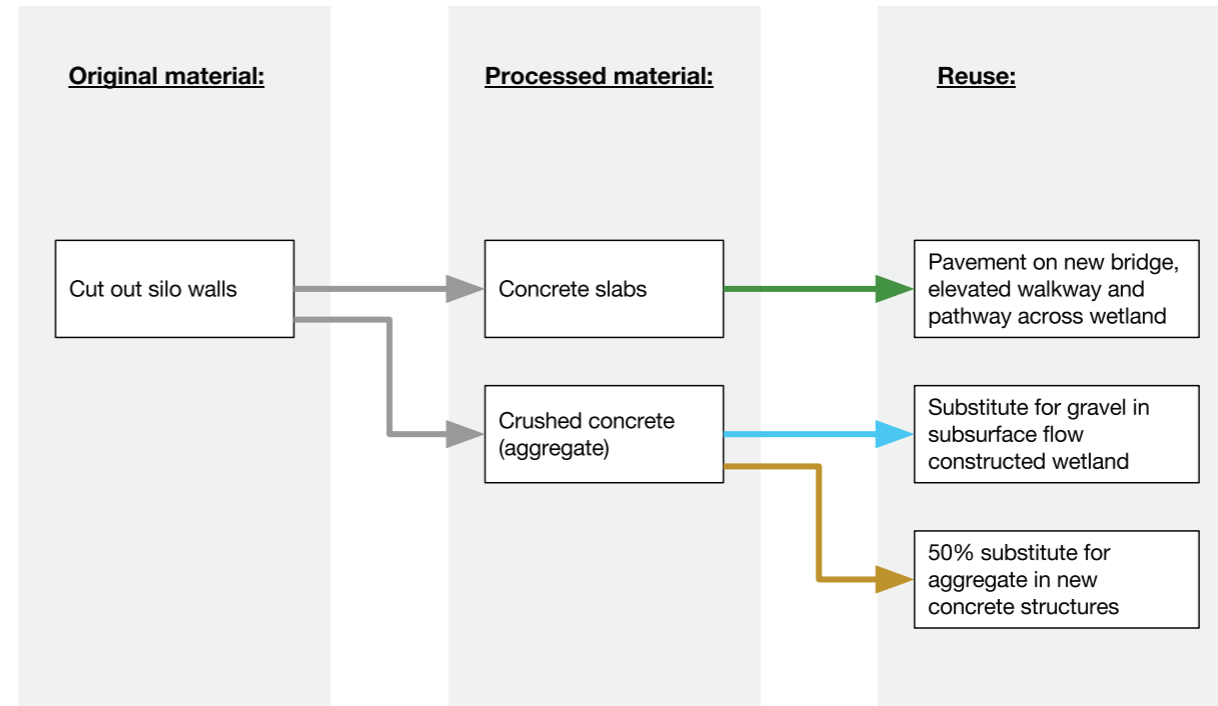


Fig. 11: Scheme for reuse of cut out concrete silo walls.



Fig. 12: Examples of one-on-one reuse of cut out silo walls as large pavement panels.

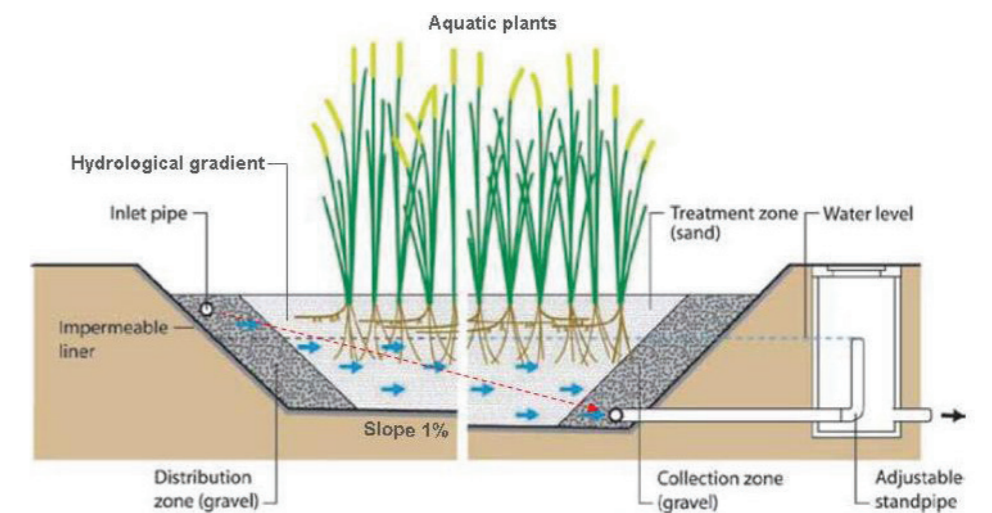


Fig. 13: Horizontal subsurface flow constructed wetland. Gravel in the distribution and collection zone can be replaced by reused concrete aggregate.

(thermal) ENERGY - SUMMER

The remaining circular system for the Maassilo is the (mainly thermal) energy system. The functioning of this system during the summer is shown in figure 14. The system consists of energy sources, processing systems, use and ventilation systems.

Energy sources in the Maassilo are solar panels on the roof, industrial heat which will be elaborated on on the next page, and heat-cold storage. Most of the roof surface will be covered with a green-blue roof as explained earlier. Solar panels, facing south at an optimal angle of 36 degrees, will be placed on top of this green-blue roof to generate electricity, like in figure 15. The green roof underneath cools off the solar panels in the summer through evaporative cooling and prevents overheating. This increases the efficiency of the solar panels with up to 26% in the summer and an average of 9-16% throughout the year. In addition to the passive evaporative cooling by the vegetation on the green roof, the solar panels can be installed with an additional water-cooling system where chilled water pipes run underneath the solar panels to cool them even more, as shown in figure 16. The electricity generated by the solar panels can be used in electric boilers for hot tapwater, to power the glycol cooling system in the brewery and to power the air cooling systems in the brewery and theatre functions.

The entire building will be climatized by floor heating, and in the summer this system will be used for basic cooling as well. Part of the silos in phase 3 next to the brewery will be used as heat-cold storage. These silos will be outfitted with a thick layer of thermal insulation to contain all thermal energy. During the summer months, water from the cold storage will transmit its cold to the floor heating system with the help of a heat exchanger that will store the returned heat in the heat storage.

Each new function in the Maassilo will have its own ventilation system with heat exchanger. The highly climatized spaces in the building, mostly in the brewery and theatre, will have additional air cooling systems.

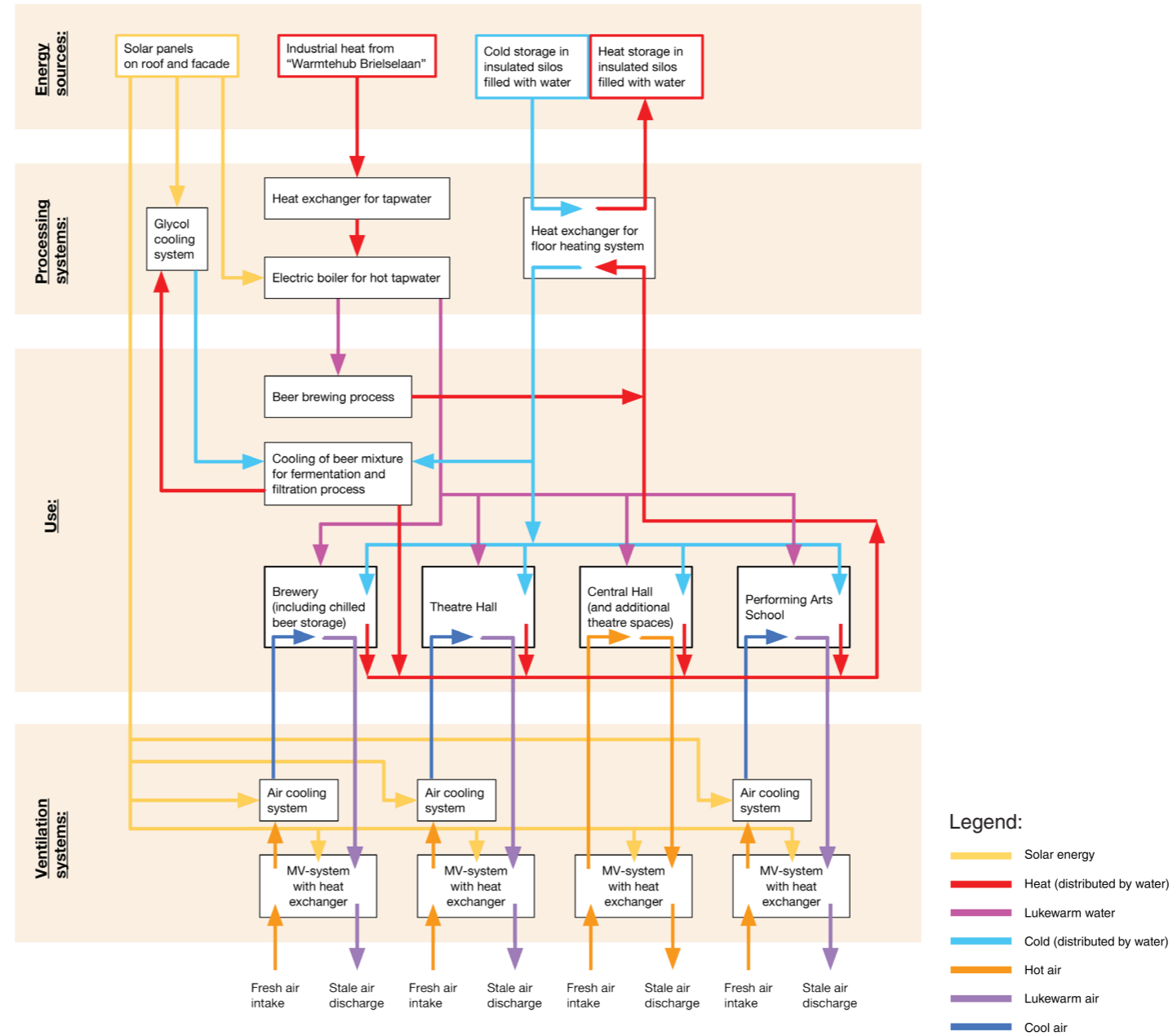


Fig. 14: Circular system for (thermal) energy during the summer.



Fig. 15: Solar panels placed on an extensive green roof.

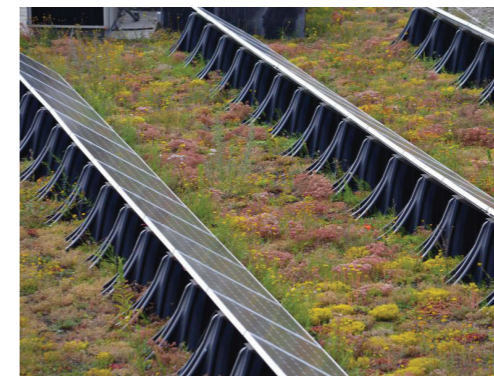


Fig. 16: Solar panels placed on an extensive green roof with additional water-cooling system.

(thermal) ENERGY - WINTER

In the winter scenario of the circular energy system, displayed in figure 17, most of the arrows have turned around to provide the building with heat instead of cold.

The floor heating system was chosen because it radiates heat to its immediate surroundings and evenly spreads the heat across the floor. This is useful in high spaces that don't need to be heated everywhere, but only need to be climatized in the zones where people are passing through or carrying out activities.

In addition to the heat that is generated in the brewing process, the primary heat source is the industrial heat network that transports excess heat from the harbor into the city. The current network has five above-ground installations, visible in figure 18. On one of these installations happens to be very close to the Maassilo. This is the 'Warmtehub Brielselaan', located further along the same street as shown in figure 19 and 20. I am choosing to use this Warmtehub with industrial heat for heating up the building instead of trying to be completely self sufficient, since this would be difficult and expensive to realise on the site of the Maassilo and might have a lot of impact on the existing building and its cultural values when every part of the building is focussed on generating heat. Using the already generated leftover energy from the industrial network is just as sustainable and easy to realise with the existing installation nearby.

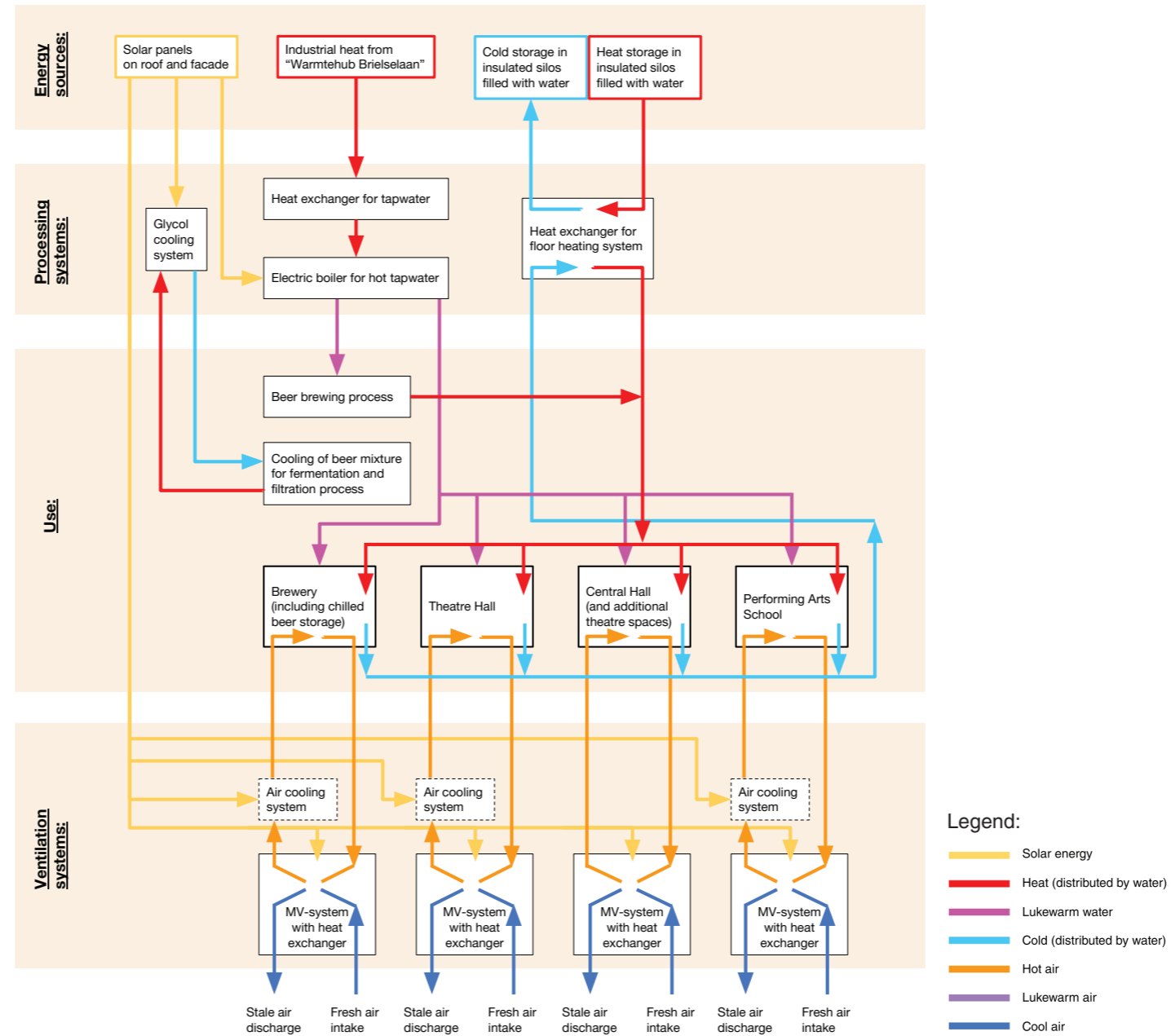


Fig. 17: Circular system for (thermal) energy during the winter.

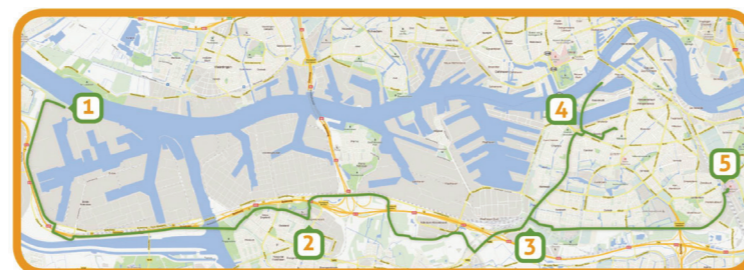


Fig. 18: Industrial (harbor) heat network in Rotterdam. Number 4 indicates the heat transmission station near the Maassilo.

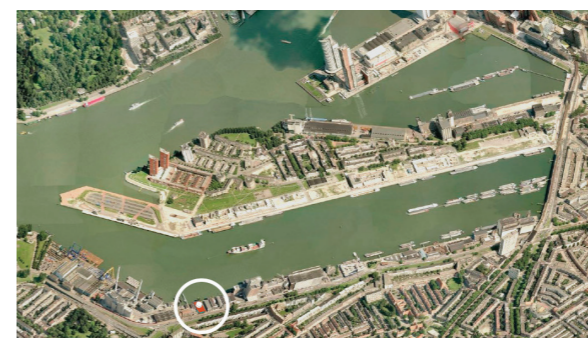


Fig. 19: Location of 'Warmtehub Brielselaan' in the white circle, on the same street as the Maassilo.



Fig. 20: Harbor-heat transmission station 'Warmtehub Brielselaan'.