Miscanthus, a Powerplant in Parkstad

Tu Delft

AE / Harvest

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Student: Hatto Kienhuis

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From green to black
An introduction to Miscanthus
Implementing Miscanthus in Parkstad
Potential of Miscanthus

Part II

Location & program
The factory
The hoeve

FROM GREEN TO BLACK

Timeline

Carboon



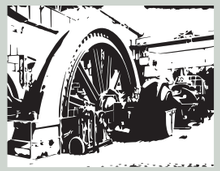


Corriovallum

Heerle

First Mines

Expansion



Industrial Revolution

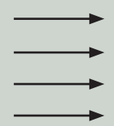
Closing Mines

IBA











300.000.000 BC

0

1065

1900

1930

1975

2018

Coal

Agriculture

Mining

Decline

New input

x 1000

Green washing



Ongoing problems



Low income
€ 21.400



Low education
40-50%



Isolated area



Low birthrates
7.9 / 1000



Aging population
11/1000



Few entrepreneurs

Elzerman, K., Bontje, M., (2015). Urban Shrinkage in Parkstad Limburg, European Planning Studies, 23:1, 87-103, DOI

Former mines

EMMA
109.032.000 T

HENDRIK
61.203.000 T

ORANJE NASSAU III
38.265.000 T

ORANJE NASSAU IV
13.754.000 T

ORANJE NASSAU I
31.978.000 T

LAURA
31.885.000 T

JULIA
31.963.000 T

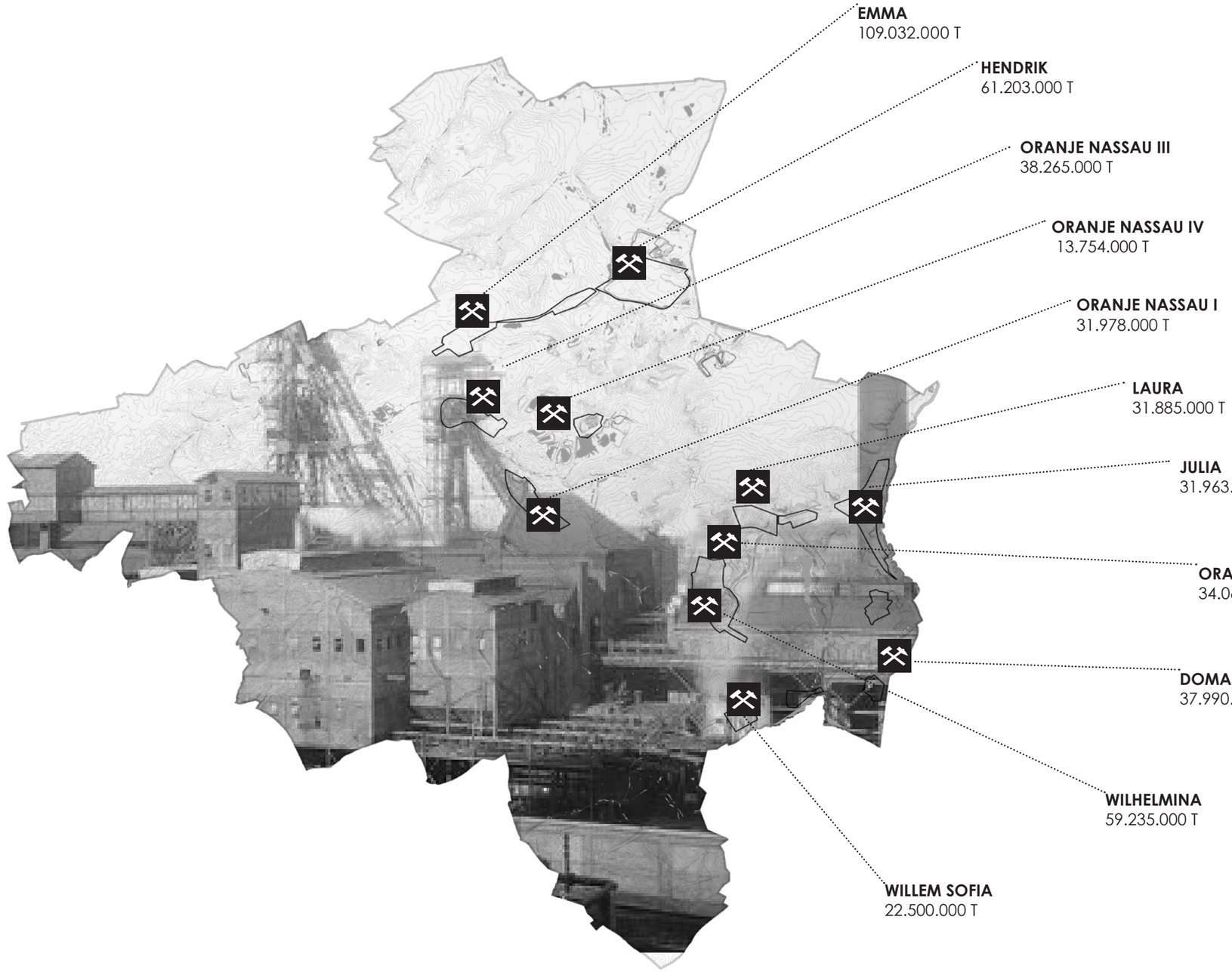
ORANJE NASSAU II
34.064.000 T

DOMANIALE
37.990.000 T

WILHELMINA
59.235.000 T

WILLEM SOFIA
22.500.000 T

In total:
471.869.000 T



1899 - 1974
Coal mines in Parkstad

A Black period ...



1899 - 1974
Coal mines in Parkstad



471.869.000.000 kg
of coals mined in Parkstad





*1.887.476.000.000 kg

of CO2 emission

4 grams of CO2 for every 1 gram
of coal being burned

150.000.000.000 kg

byproduct of of minestone&-silt

Balsum, T. et.al, 2003, Omgaan met mijnsteen in parkstad Limburg, Stichting Kennisontwikkeling Kennisoverdracht Bodem , Gouda

Powerplant



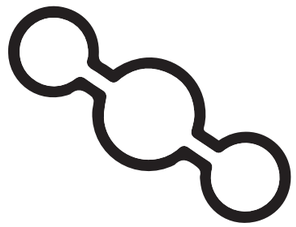
<

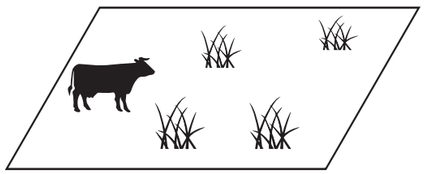
2-3 x more absorbtion of CO_2



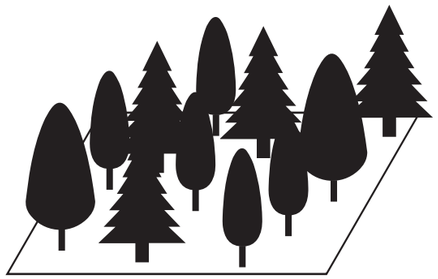
<

4 x more absorbtion of CO_2

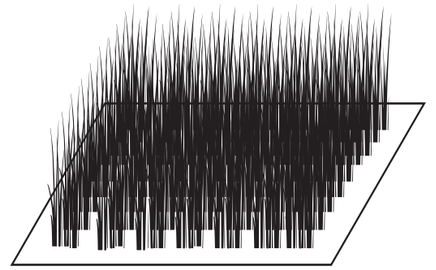




1 ha of grass
3-4 tonnes of CO_2

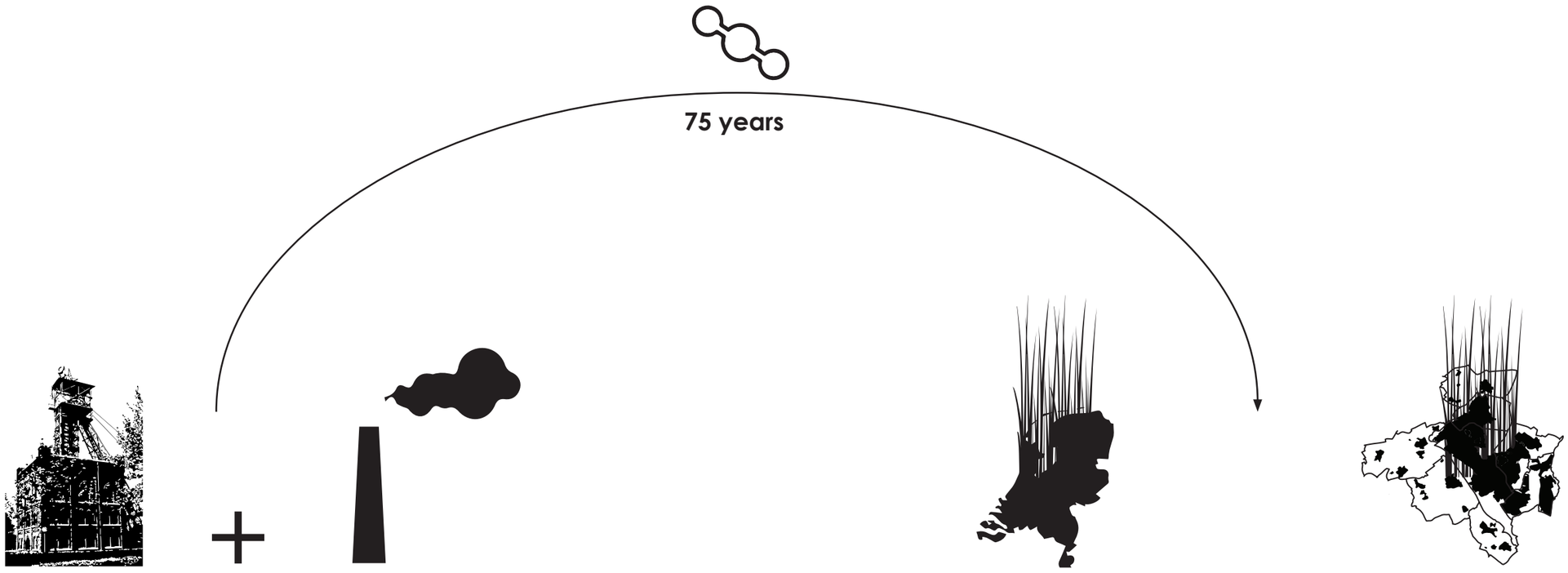


1 ha of forest
10 tonnes of CO_2



1 ha of Miscanthus x Giganteus
40 tonnes of CO_2

Closing the loop



Coals from Parkstad

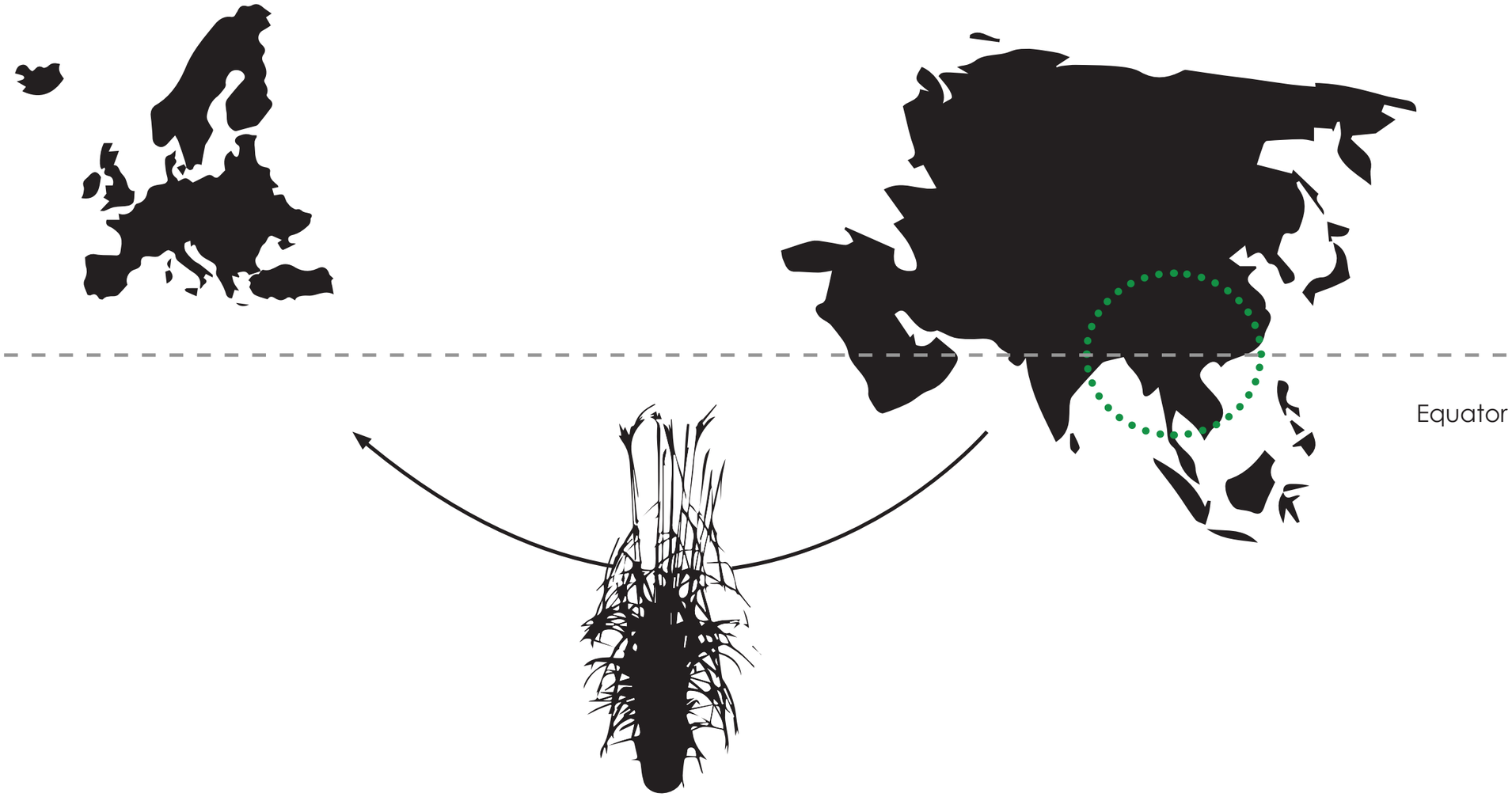
Netherlands 42.508.000 Ha

Parkstad 21.000 ha

AN INTRODUCTION TO MISCANTHUS



Ornamental Grass



Introduced in Europe as ornamental plant
from South East Asia.

Ingredients



Parkstad

pH 5.5 - 7.5
Loss soil

+



CO_2

40.000 kg / ha

24.500 kg CO2-eq
ha1 yr1

+



Rhizomes

20,000 / ha



Miscanthus
x
Giganteus

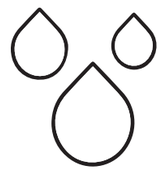
+



Fertilizer

Season 1-2
150 kg / ha

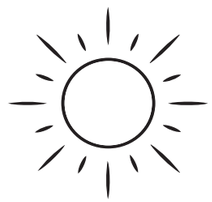
+



Water

> 600–700 mm
(822mm)

+



Temperature

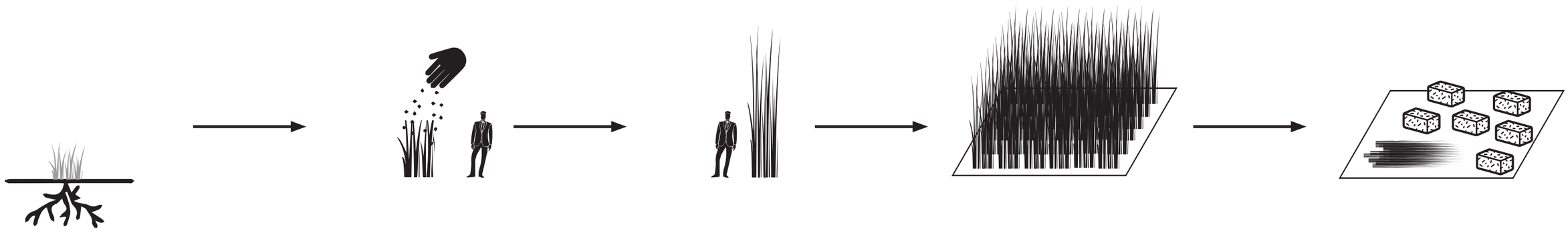
> 6 Celsius

Growing

20-25 years cycle

First 1-2 years

1x per year



Rhizomes

Spring

Fertilizer

Season 1-2
150 kg / ha

Growth

Summer
max 4m1 heigh

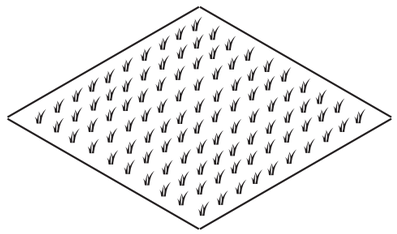
Growth

Autumn
the crop dries out, to 30-50% water in winter. The leaves will fall of and are nutrients

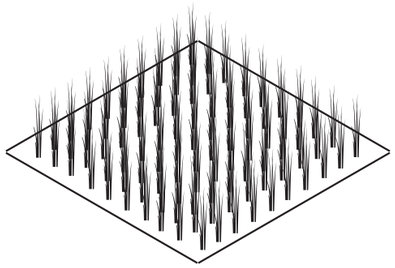
Harvest

Up to 20t/ha dry material

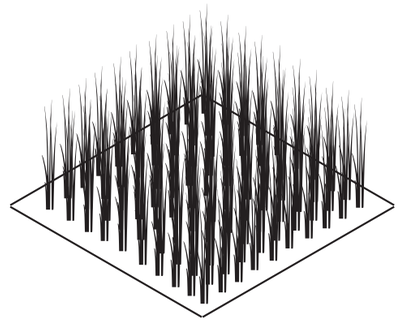
Growth & Rhizomes



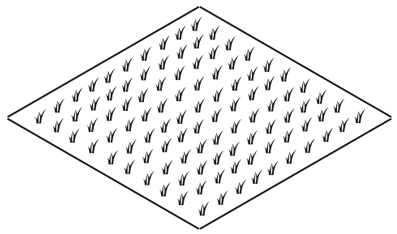
1st & 2nd year:
< 10 T dry material / ha



3rd & 4th year:
10 T dry material / ha

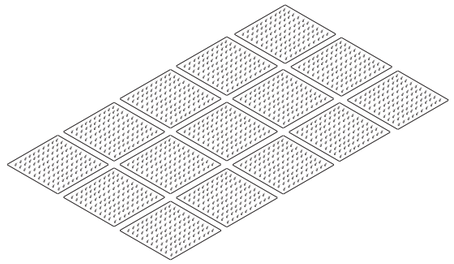


> 4th year:
20 T dry material / ha



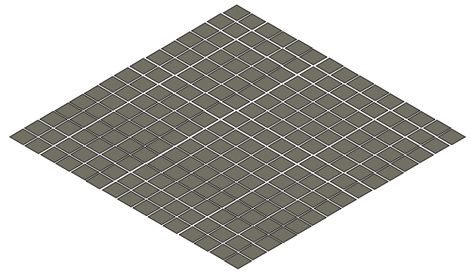
year 1 :
planting rhizomes

1 Ha



year 5 :
after 4 years the rhizomes can be spreaded

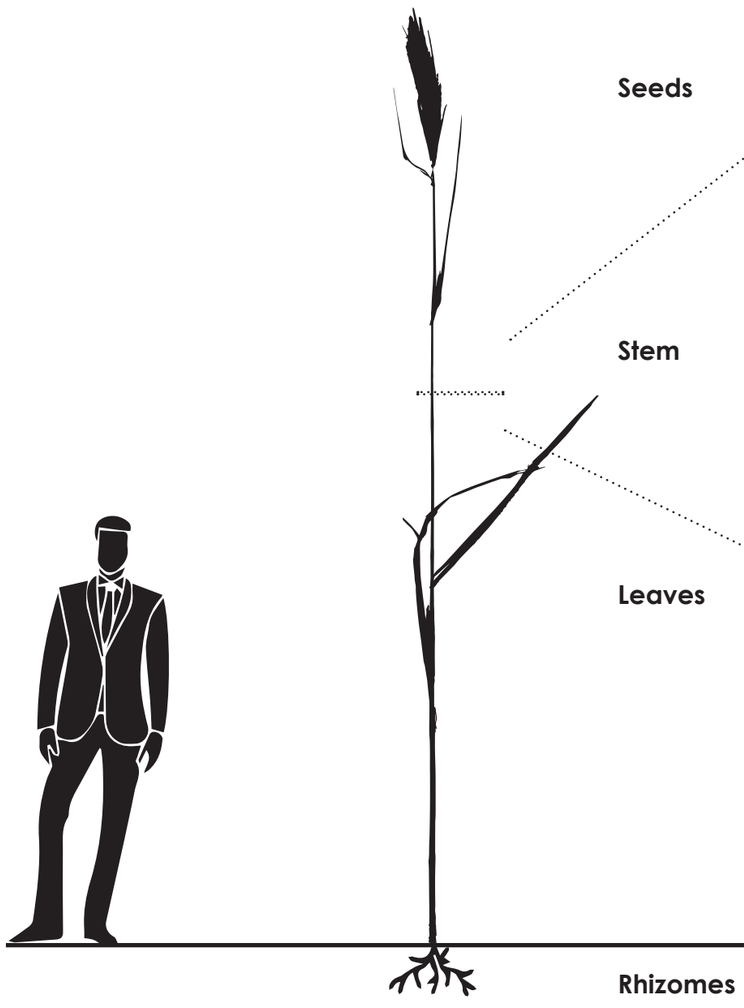
15 Ha

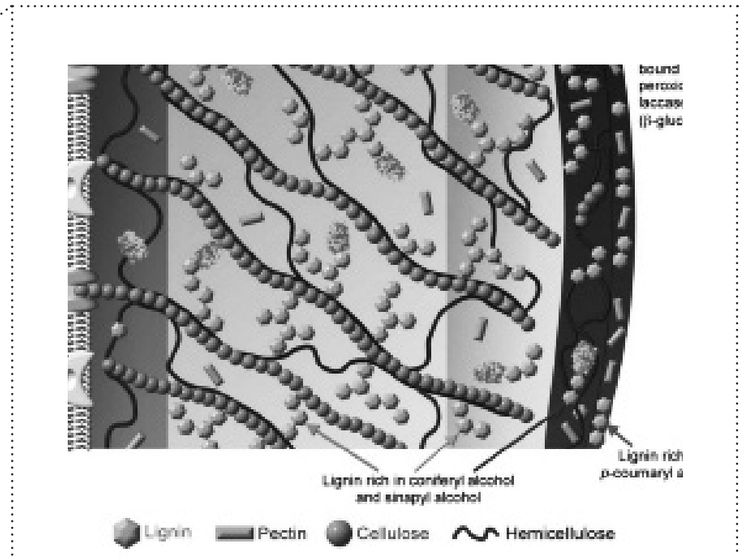


year 9 :
again the rhizomes can be spreaded

225 Ha

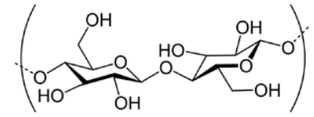
Components





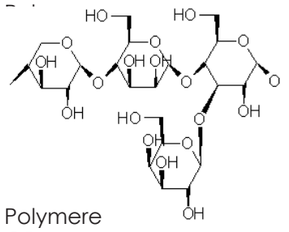
Miscanthus x Giganteus

Cellulose 40-45%:



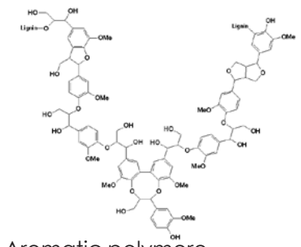
Firmness and structure
Polymere
Glucose (C6-suiker)
Degrades difficult

Hemicell 20-30%:



Polymere
C5 sugars
Easy degradable

Lignine 19-20%:



Aromatic polymere
Structural support
Resistance against microbial attack and oxidative stress

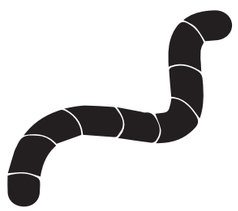
Biodiversity



3 X spiders



5 X mammal species



3 X earthworms



4 X bird species



0 X Geese

IMPLEMENTING MISCANTHUS IN PARKSTAD, THE URBANISED LANDSCAPE



Do's and Don'ts

- Should not be at the expense of agriculture / food production

- Consider the experience of landscape from roads

- Should not lead to social (unsafety) implications for neighbourhood

T. Bjerke et al. / Urban Forestry & Urban Greening 5 (2006) 35–44

- Should be easy to reach considering machinery

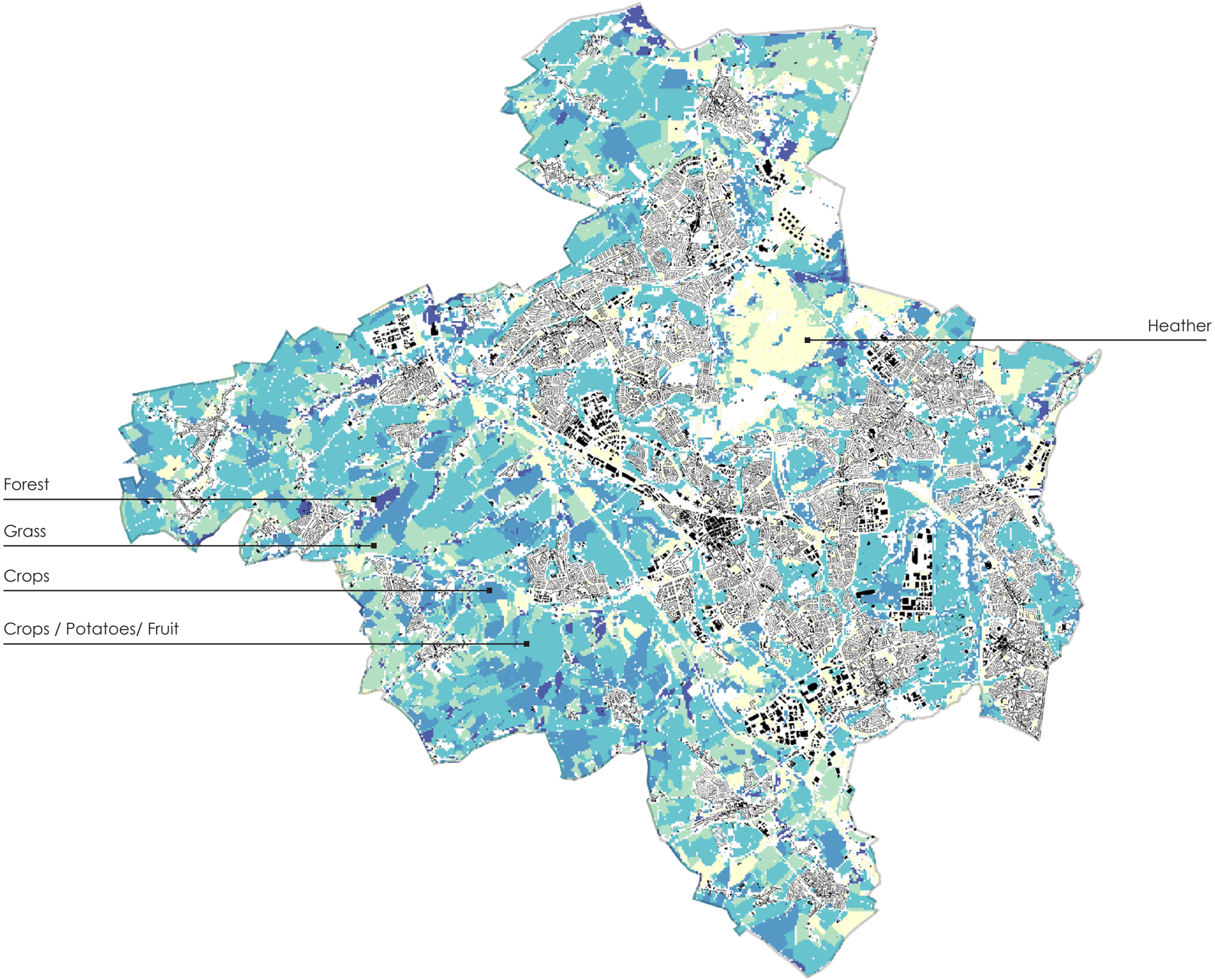
- Use land which can be used for a minimum of 6 years

- Use land with a minimum amount of 1 or 2 ha

http://www.duurzamebedrijfsvoeringoverheden.nl/downloads/alphen_aan_den_rijn_braakliggende_grond_chris_jansen.pdf

- Look at problem areas

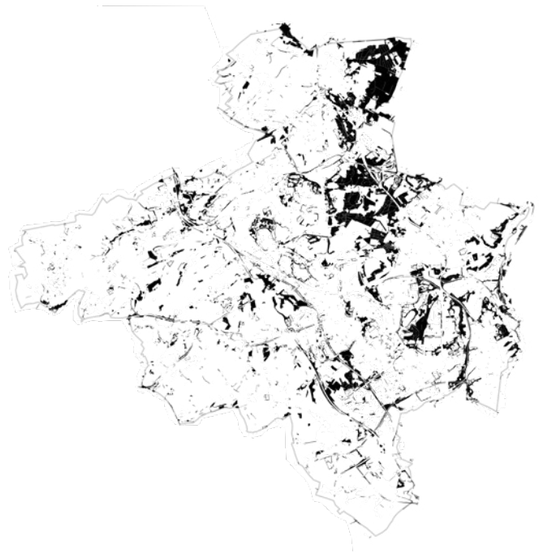
CO2 withdrawel



Terrain



Grassland, 23.9 %
5041,6 ha



Forest, 13,3%
2815,2 ha



Agriculture, 27,3%
5750,6 ha



Buildings, 7%
1485,9 ha

4 types



Along Infrastructure



Within Parkstad , unused



Empty plots on the industrial parks



Grassland dedicated to livestock

Grasslands



Grassland, 23.9 %
5041,6 ha

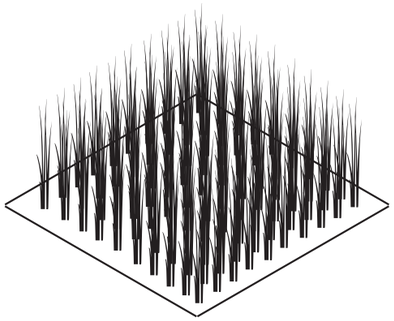


Grassland > 1ha
3973,4 ha

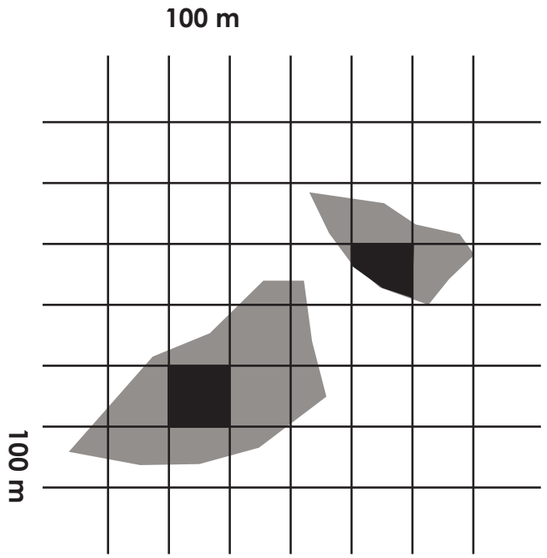


Grassland > 2ha
3160,9 ha

How and where ?



A plot of 100m by 100m

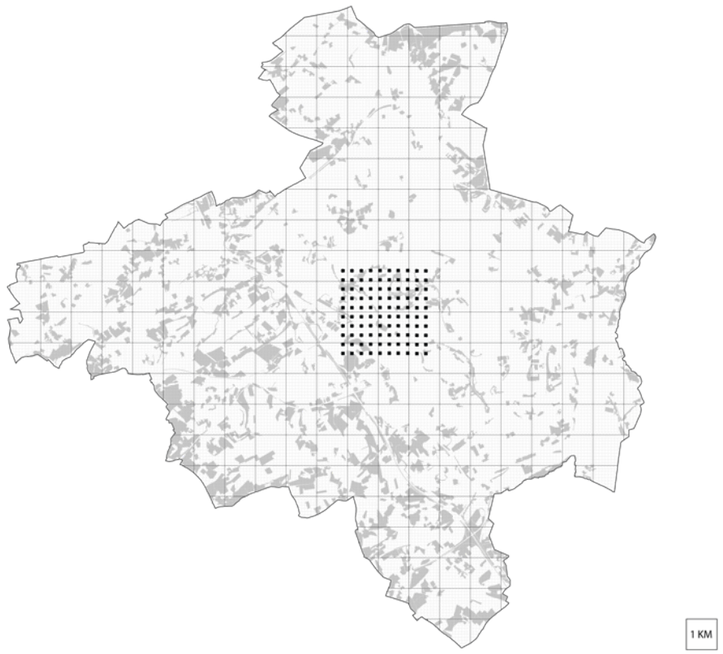


A grid in North South direction



Parkstad, an area of 21.100 ha

The grid



Organized

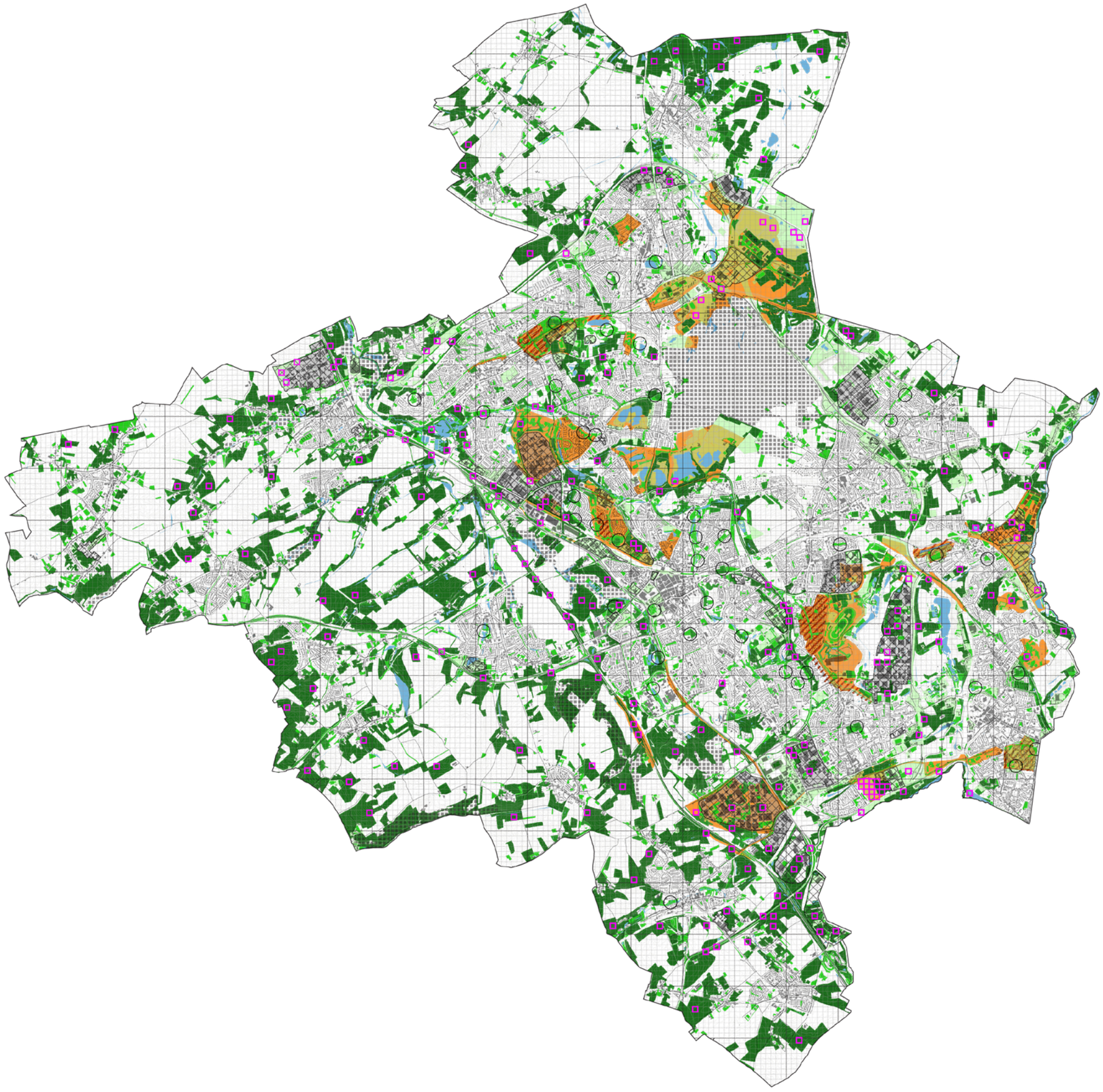


Spreaded



Near infrastructure

225 HA



LEGEND

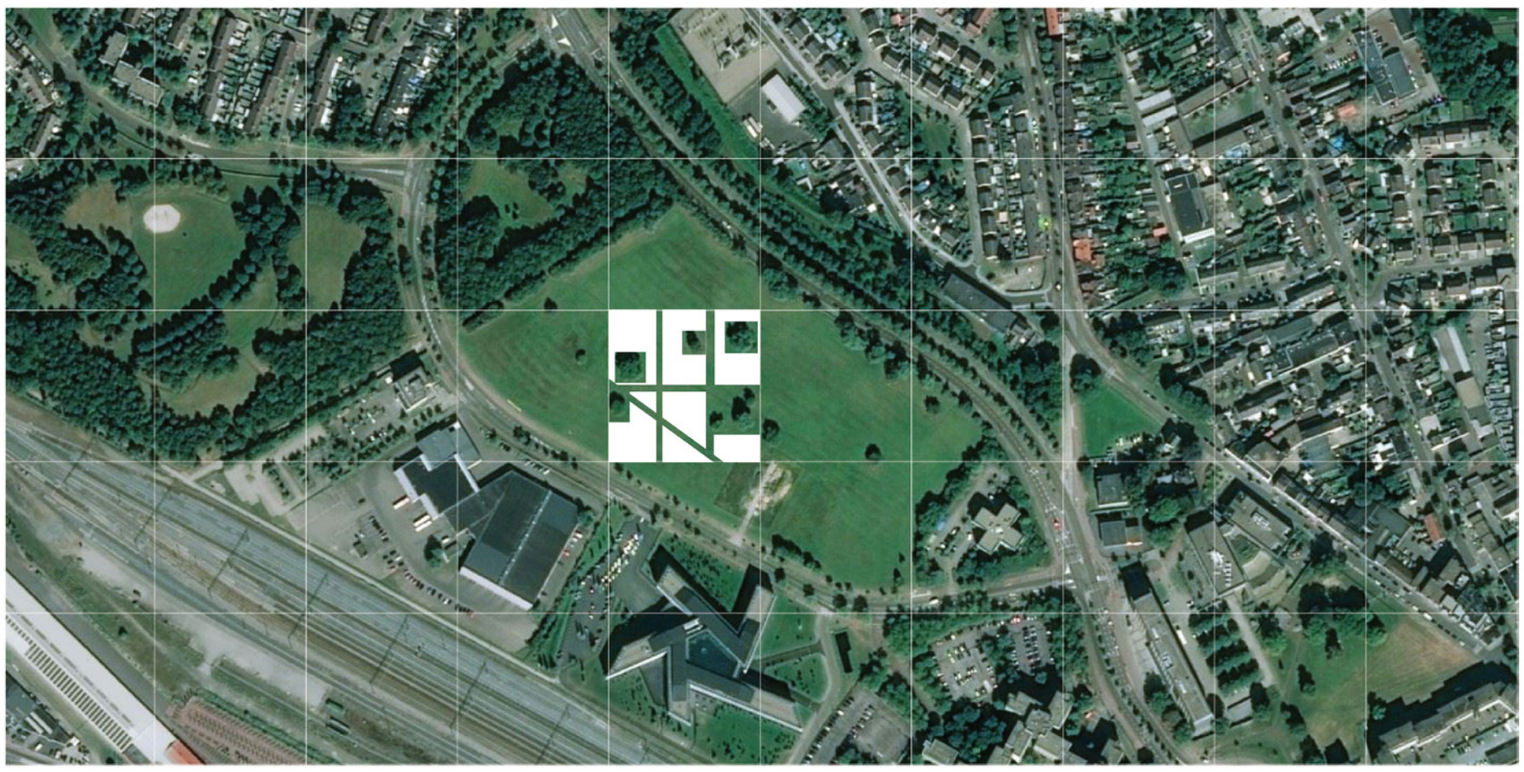
- Grassland > 2ha
- Grassland > 1 ha
- Grassland < 1ha
- Other
- Natura 2000
- Industry
- Minestone pollution
- Minestone cleaned
- 1 Ha of Miscanthus

Scale 1: 40.000

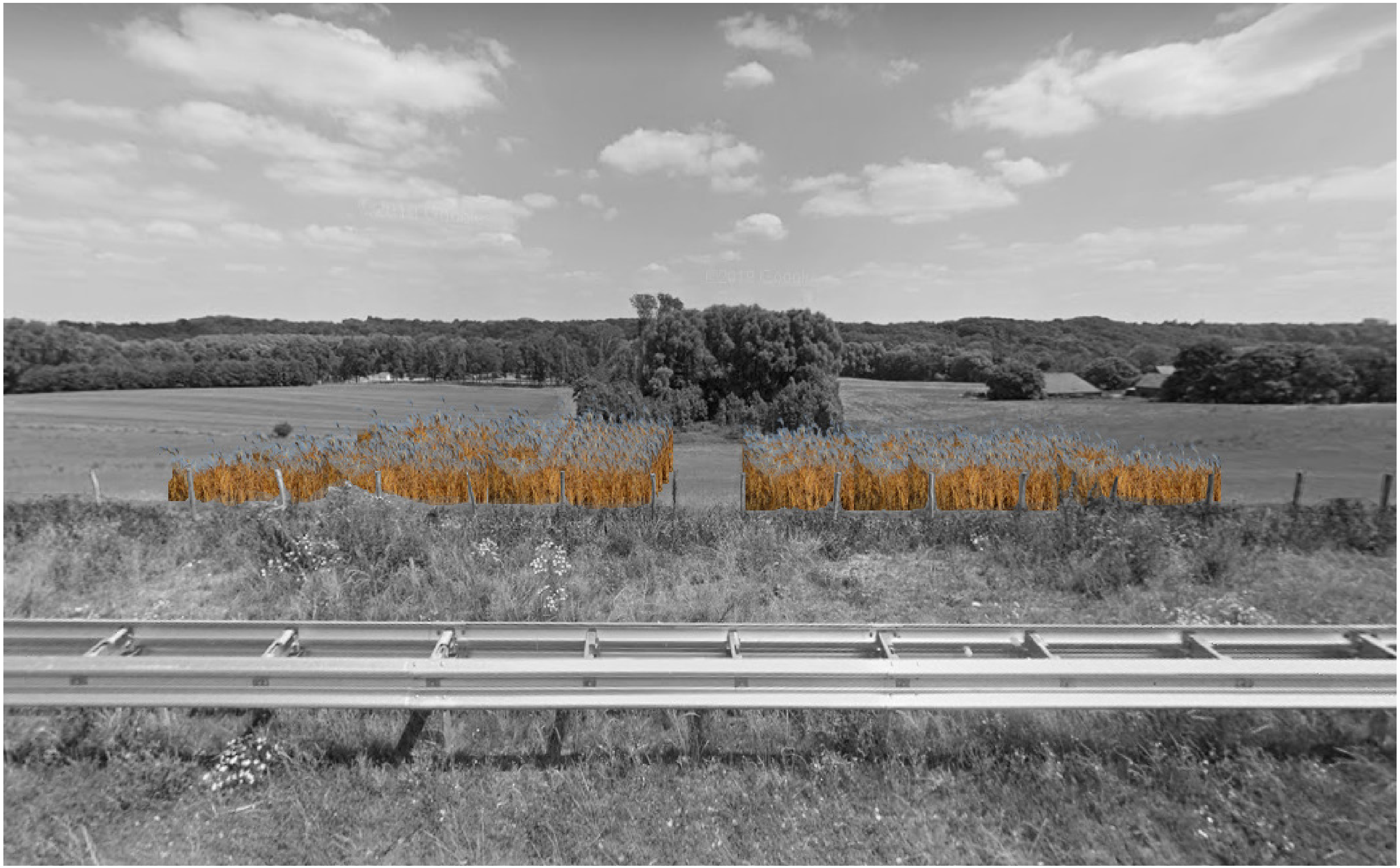
1 KM

Example I





Example II



POTENTIAL OF MISCANTHUS

Efficient & Value

Biorefinery and biomass will play an **increasingly crucial role** as we move towards a biobased economy over the coming decades. Biomass is important for supplying the growing world population with **food, energy, chemicals, materials, pharmaceuticals and other products**.

Instable supply of fossil and mineral resources as well as growing wealth lead to changes in consumption patterns resulting in an increased demand for raw materials. In the emerging biobased economy, next to securing our raw material supply, **efficient** use of biomass as raw material and **optimal value** creation are important issues.

Development of new sustainable biobased value chains is therefore a highly interesting approach. Biorefinery involves the **enabling technologies** to make this possible, as it allows for optimal utilisation as well as value creation of biomass.

WUR / 2019

https://www.wur.nl/en/Research-Results/Research-Institutes/food-biobased-research/Research-themes/Biorefinery.htm

Treatment



Fodder



Insulation



Concrete



Paper



Bioplastic



Ethanol



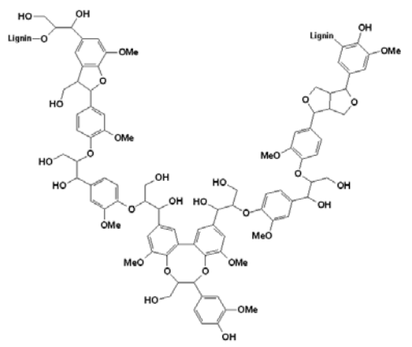
Carbon Fibre



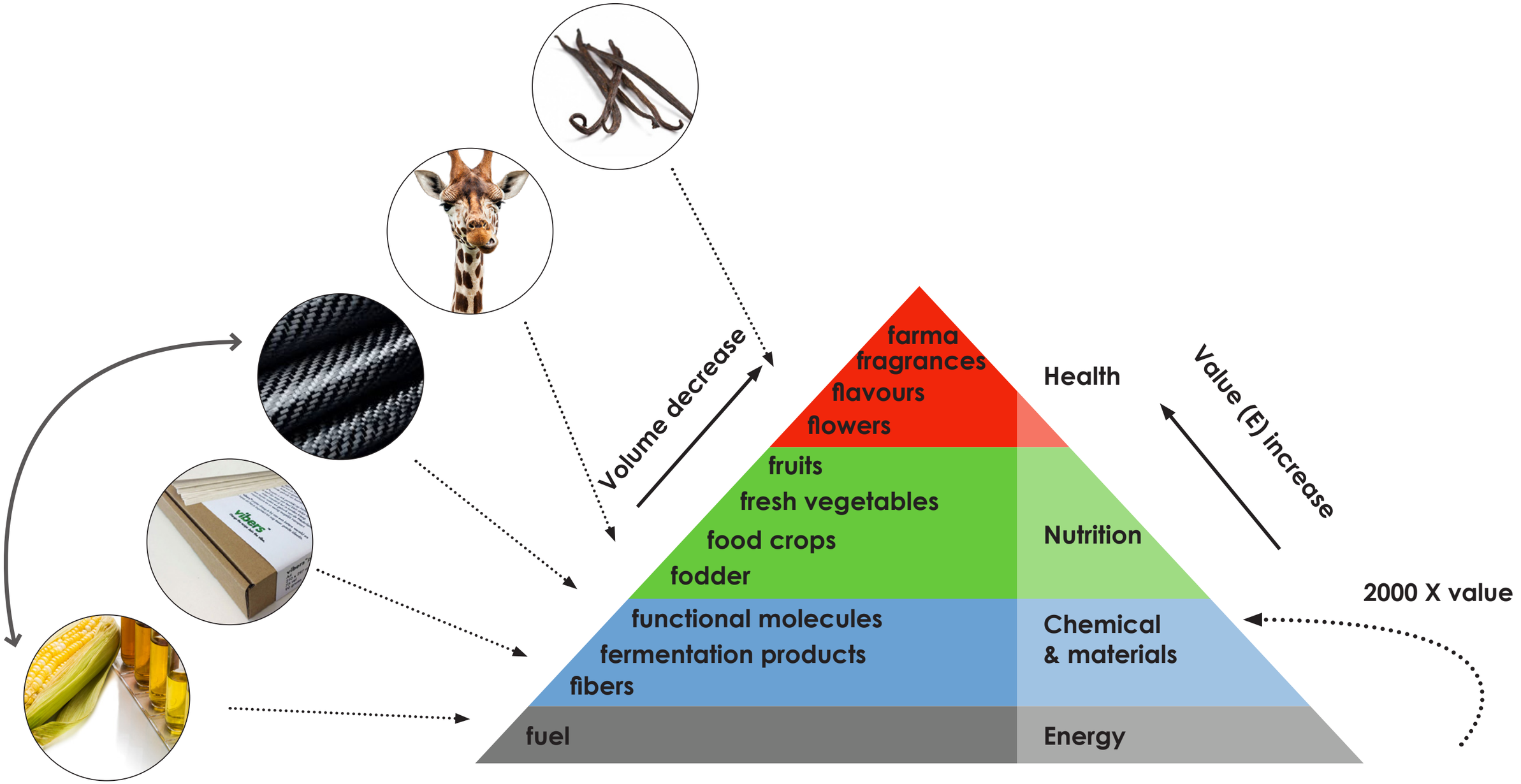
Vanillline

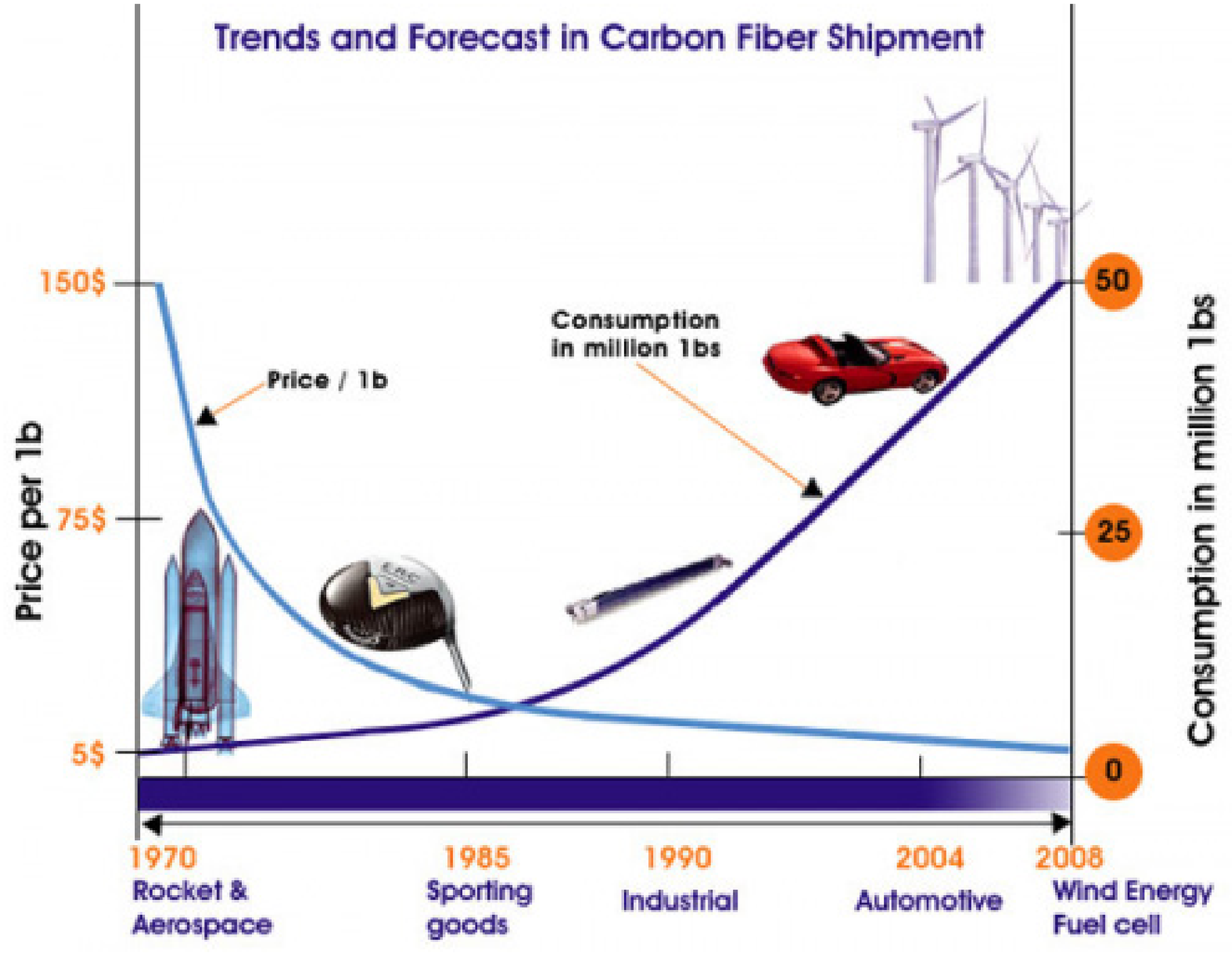


Treatment



Quantity and value





http://technotheek.utwente.nl/wiki/Koolstofvezel

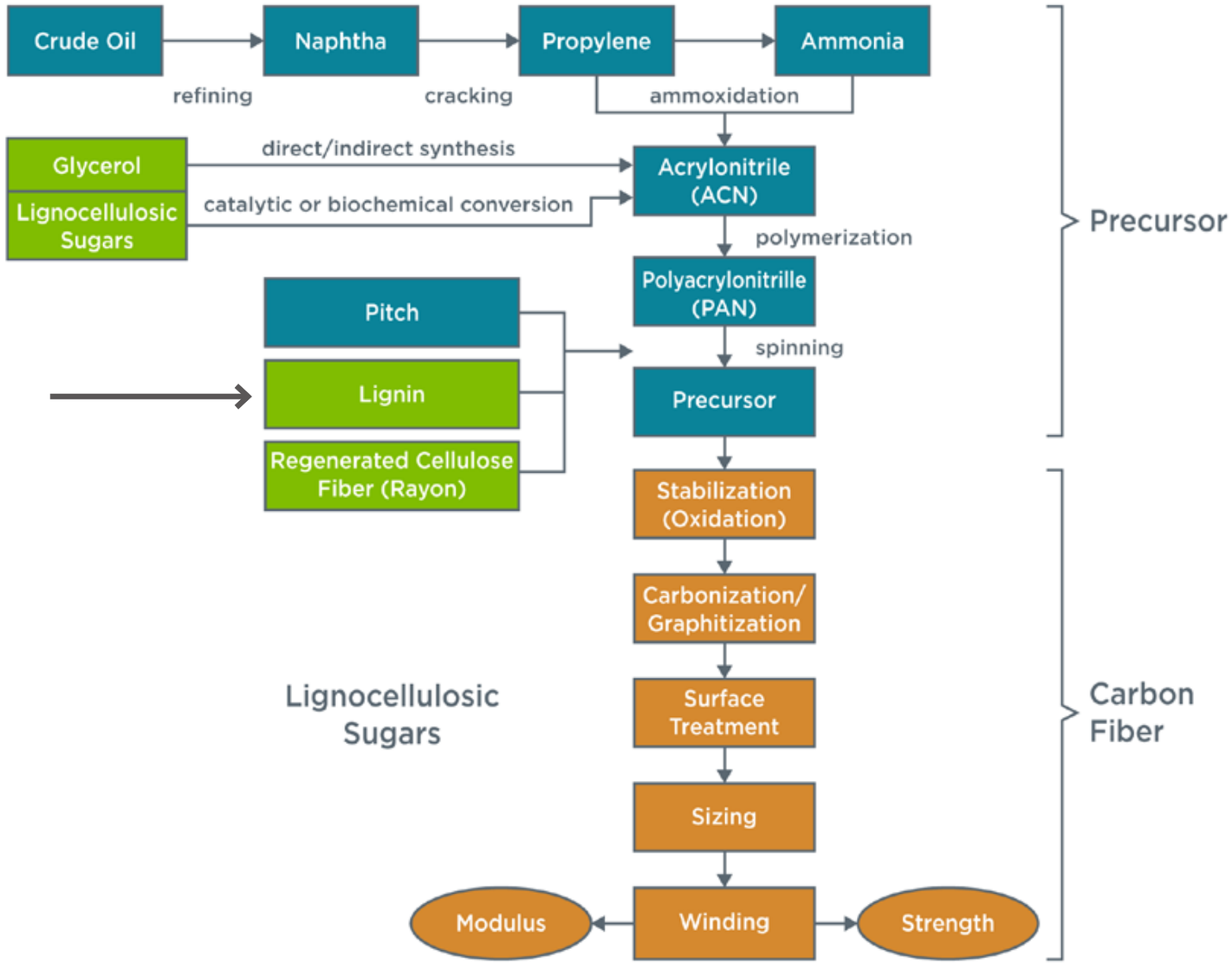
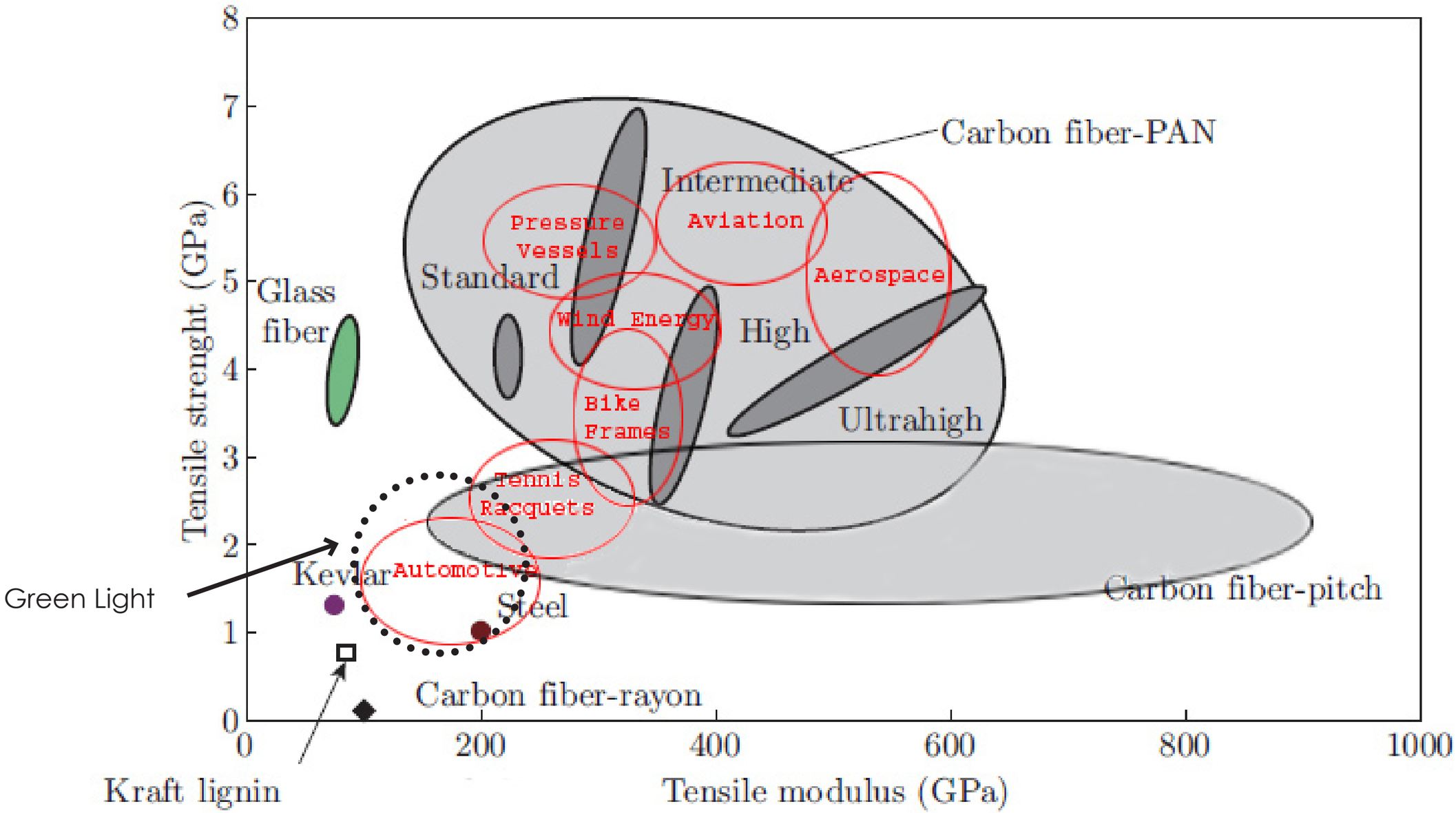


Figure 3. Carbon fiber manufacturing process from various precursors

Lignin-based carbon fiber: a current overview 2018 / Felipe Souto , Veronica Calado and Nei Pereira

Automotive industry

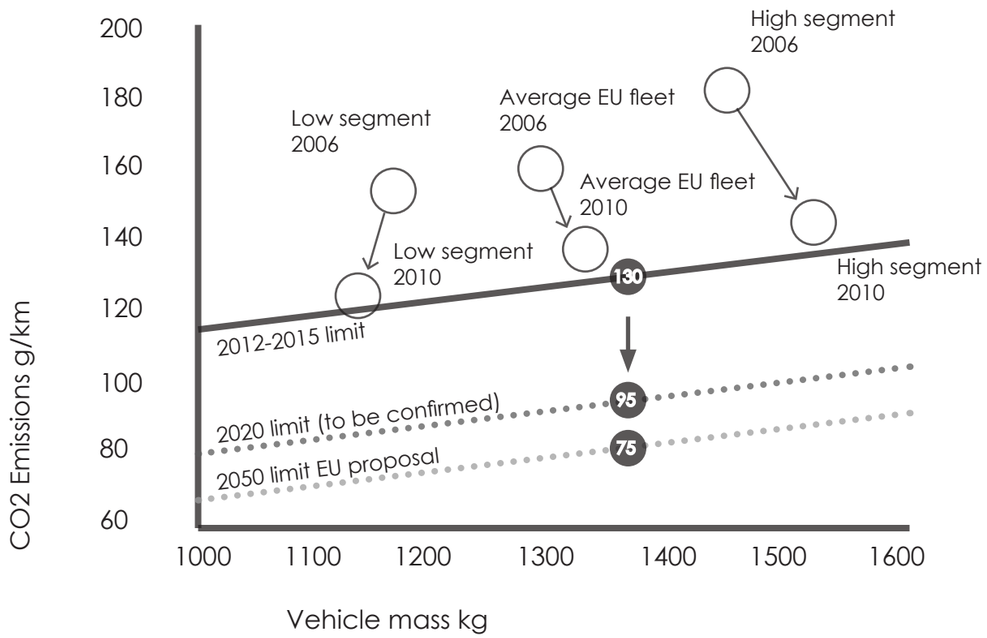


Green Light

CO2 emissions







Currently 25% of CO2 emissions comes from cars in EU

2030 : reduced by halve

From green to black



1T of Miscanthus



200 kg of Lignin



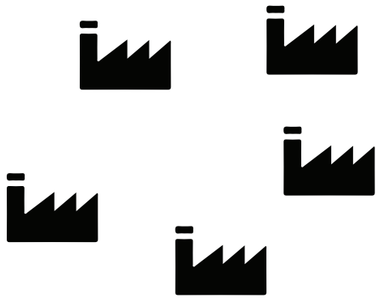
100 kg of Carbon fibre



1 carbon fibre frame
for car < 600kg



Parkstad



Network with biorefinery of
lignocelluloce biomass

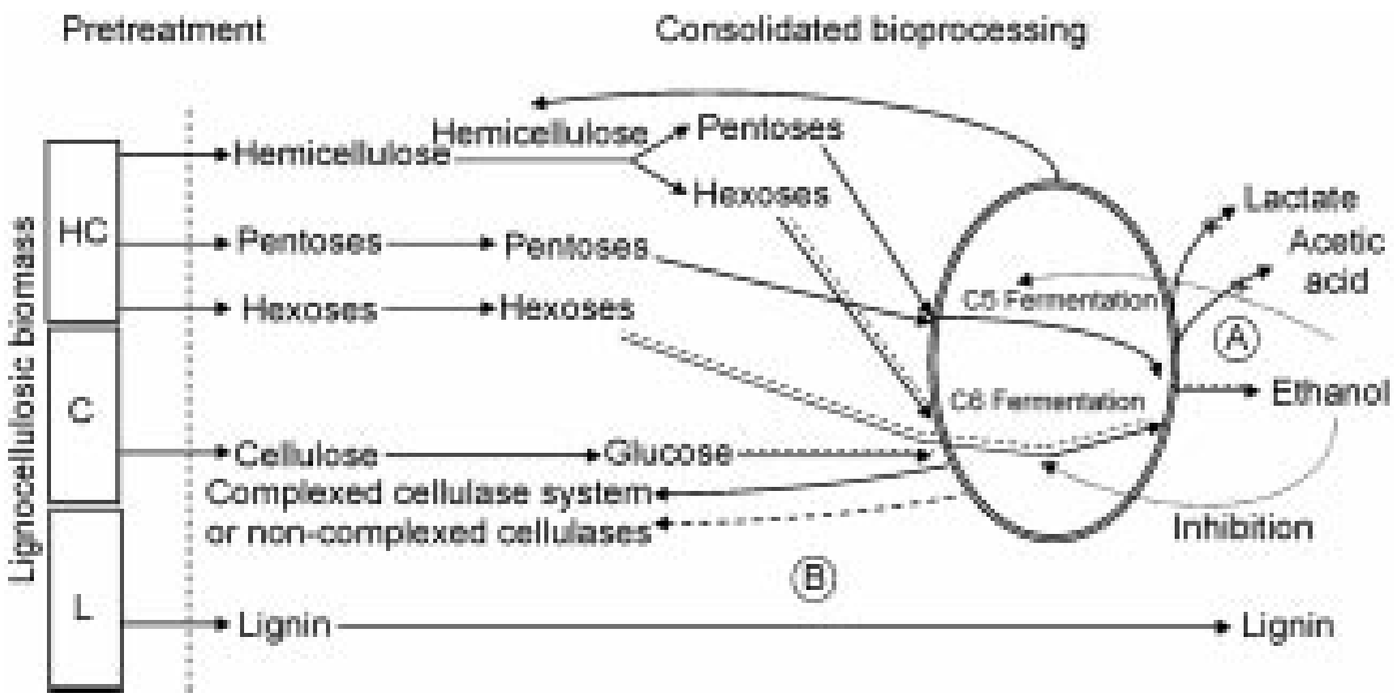


Factory in Parkstad , DSM ??



Car factory in Born

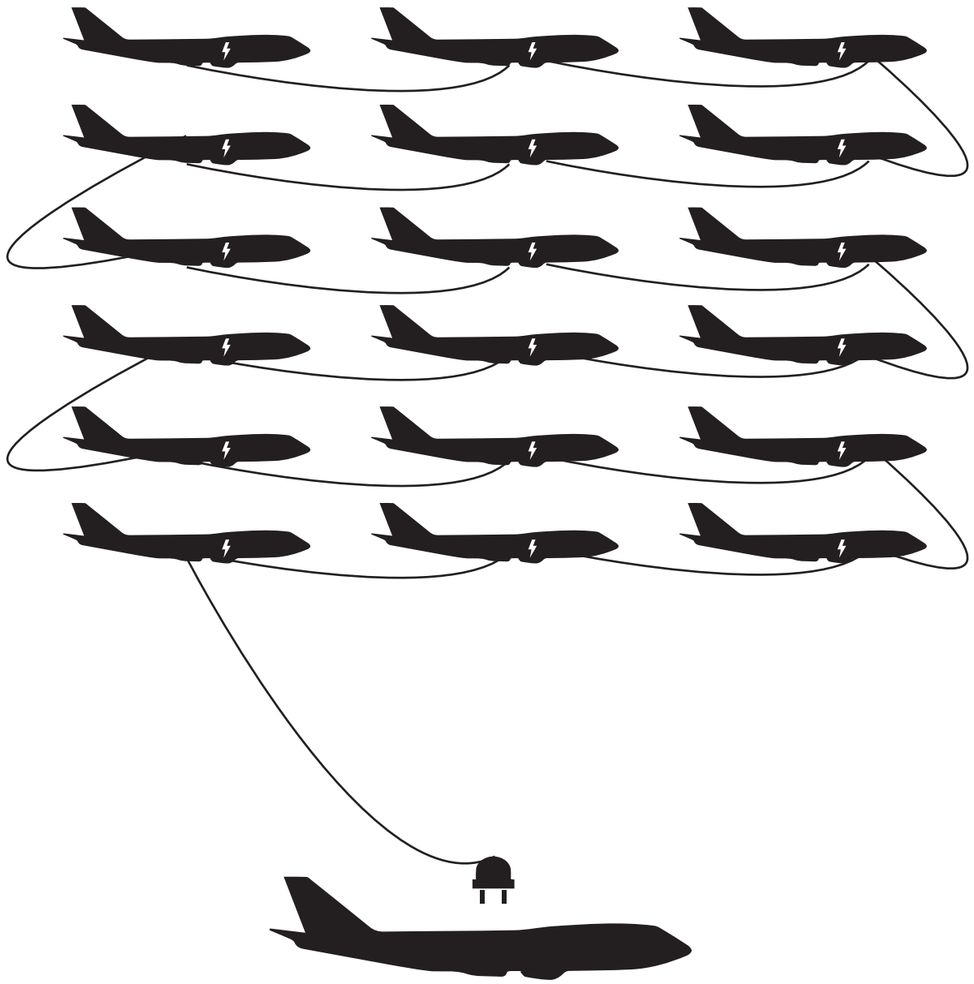
Formula


Pretreatment
Consolidated bioprocessing
Lignocellulosic biomass
HC
C
L
Hemicellulose
Pentoses
Hexoses
Cellulose
Glucose
Lignin
Hemicellulose
Pentoses
Hexoses
Pentoses
Hexoses
C5 Fermentation
C6 Fermentation
Lactate
Acetic acid
Ethanol
Complexed cellulase system
or non-complexed cellulases
Inhibition
A
B
Lignin

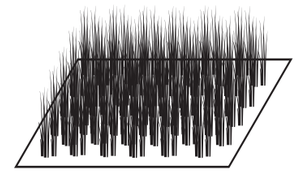




Why ethanol



18 x Boeings filled with batteries to fly electric



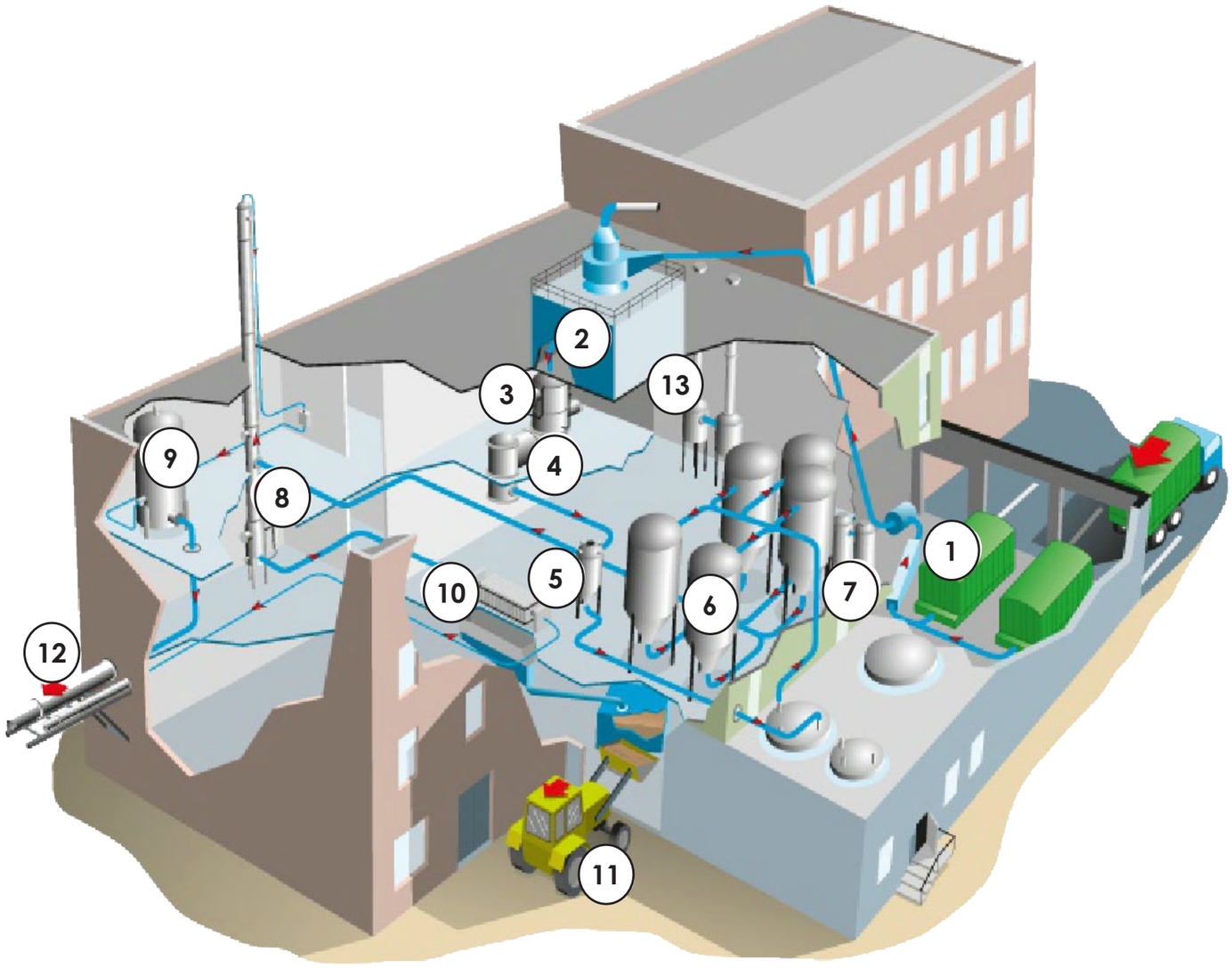
310 liter of bioethanol per T Miscanthus



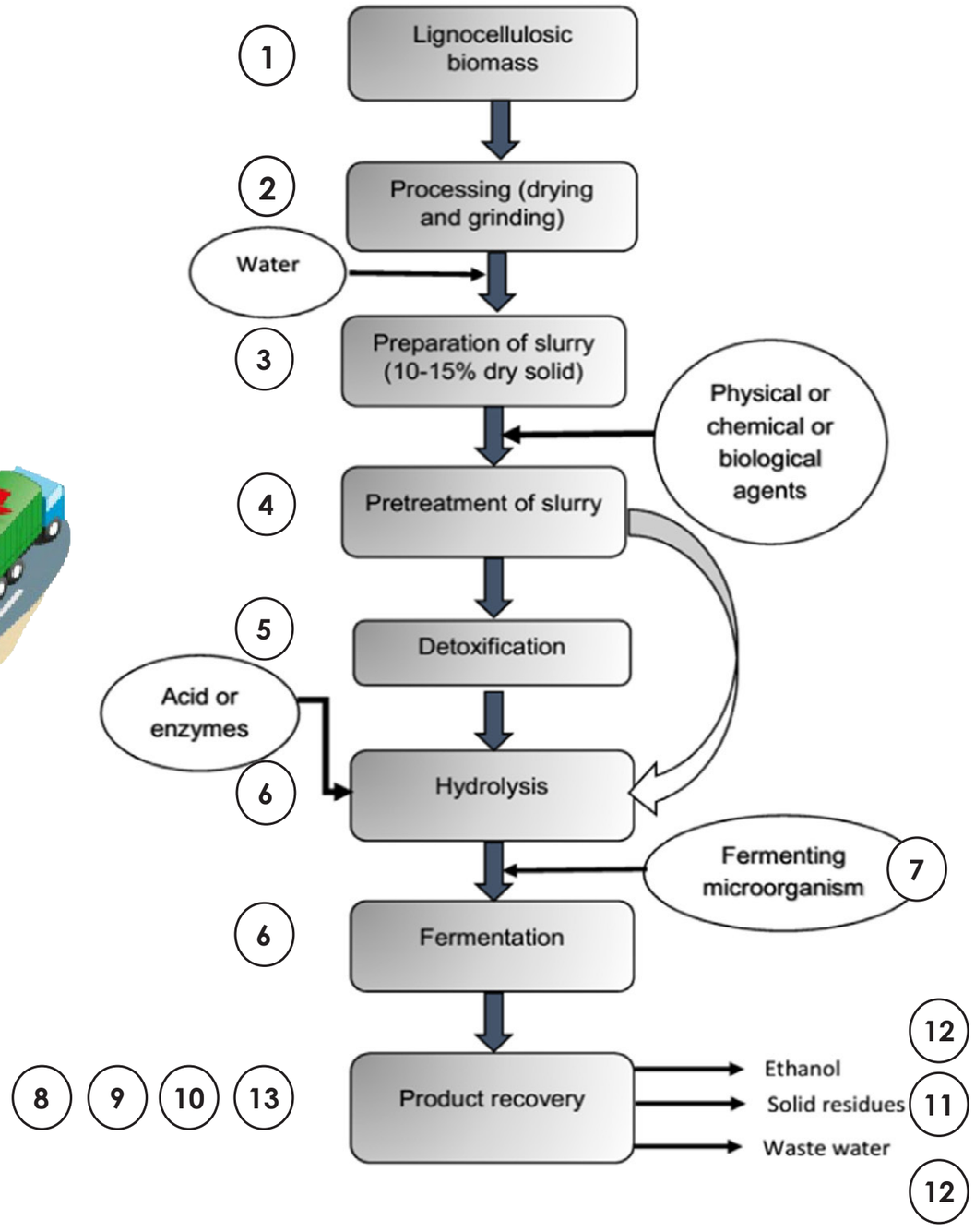
50.000 liter annually



Demoplant



Pilot lignocellulosic refinery, Sekab.com



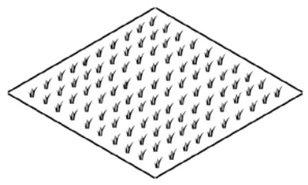
H. Zabed et al. / Renewable and Sustainable Energy Reviews 66 (2016) 751–774

LOCATION & PROGRAM

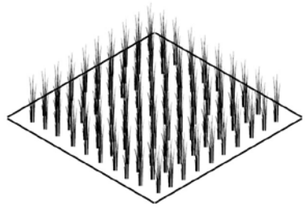


Timeline

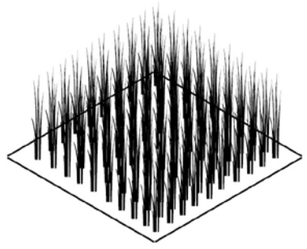
Growth



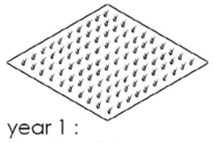
1st & 2nd year:
< 10 T dry material / ha



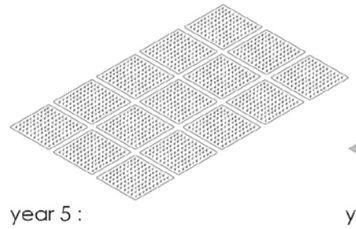
3rd & 4th year:
10 T dry material / ha



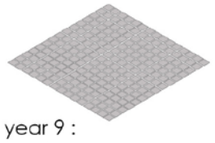
> 4th year:
20 T dry material / ha



year 1 :
planting rhizomes

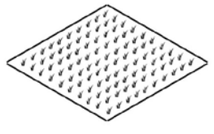


year 5 :
after 4 years the rhizomes
can be spreaded

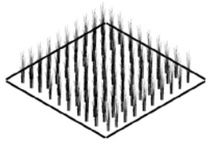


year 9 :
again the rhizomes
can be spreaded

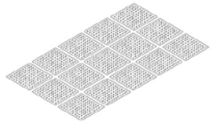
Landscape



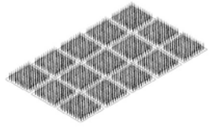
1 Ha



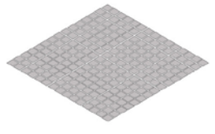
1 Ha



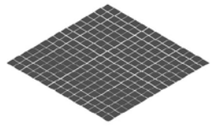
15 Ha



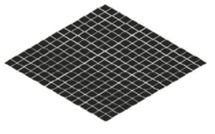
15 Ha



225 Ha



225 Ha



225 Ha

Timeline

2020 — 2024 — 2025 — 2028 — 2029 — 2032 — 2033

Fertilizer

Season 1-2
150 kg / ha



0.15 T



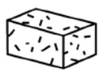
2.25 T



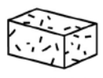
33.75 T

Harvest

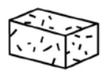
Bales (0.48x0.8 x 0.35)
density of 133kg/m3



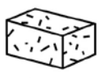
10 T
x 559



150 T
x 8.385



2250 T
x 125.775



4500 T
x 251.550

Processing

- Ethanol 300L/T
&
- Carbon fibre 100kg/T

- Insulation
- Fodder
- Burning for energy

- Biogas
- Fertilizer

- Insulation
- Fodder
- Burning for energy

- Biogas
- Fertilizer

- Ethanol 675.000 liter



x 14

- Carbon fibre 225 T

- Ethanol 1.350.000 Liter



x 28

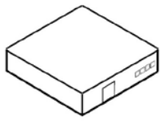
- Carbon fibre 450 T

Building

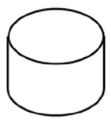




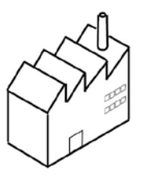
- Biofertiliser



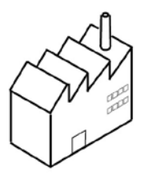
- Empty factory hall



- Biofertiliser

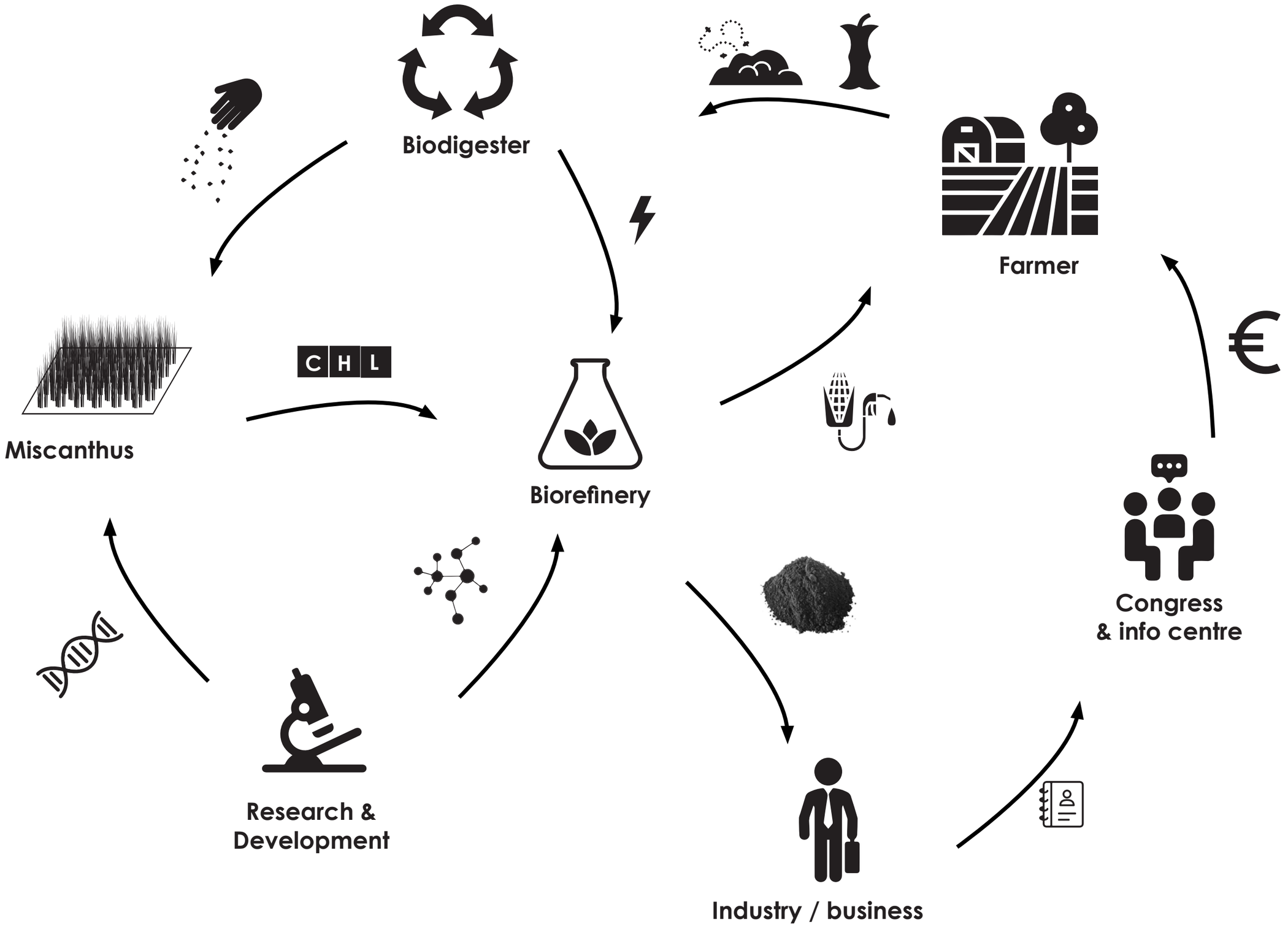


- Biorefinery

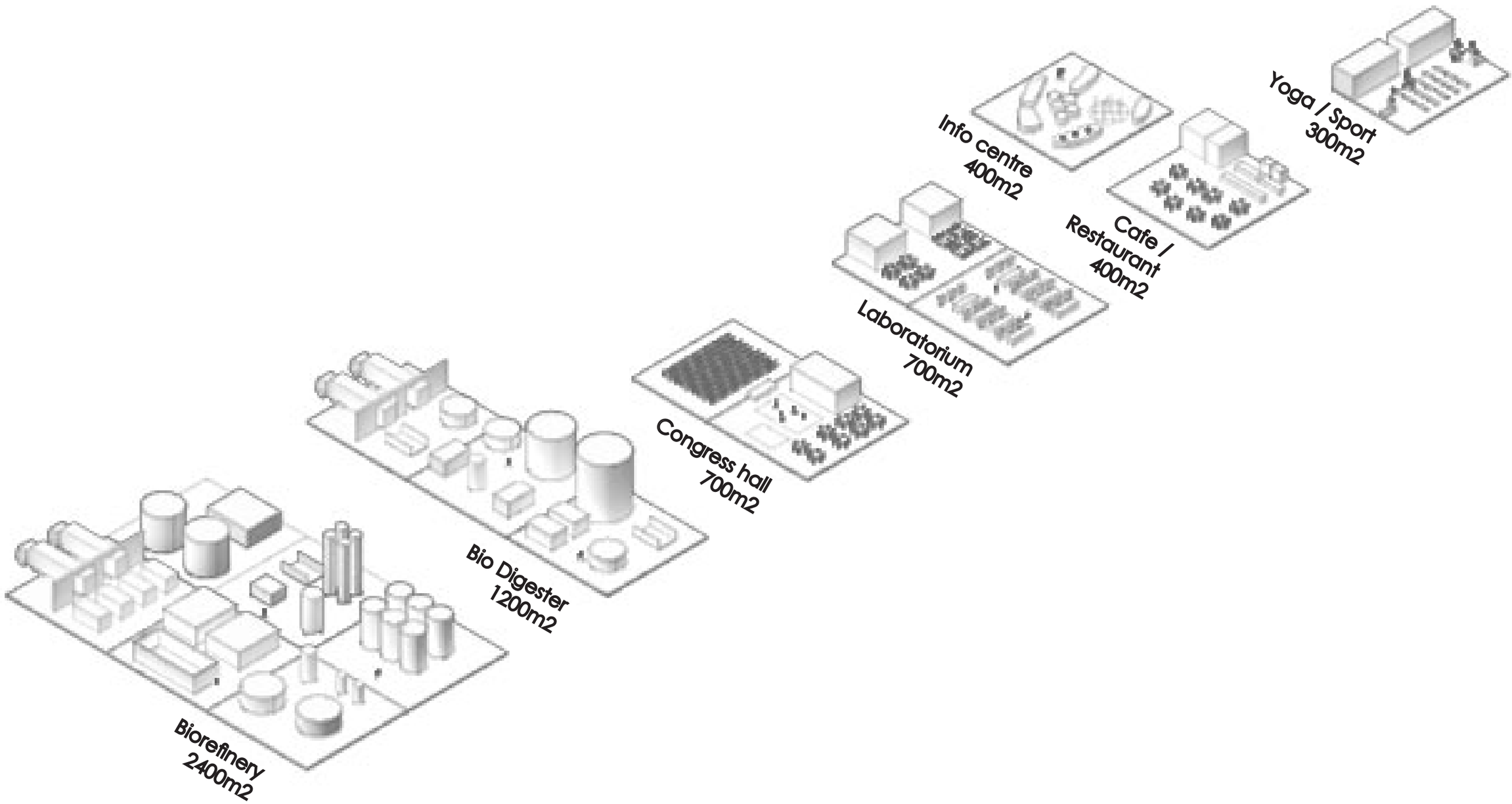


- Biorefinery

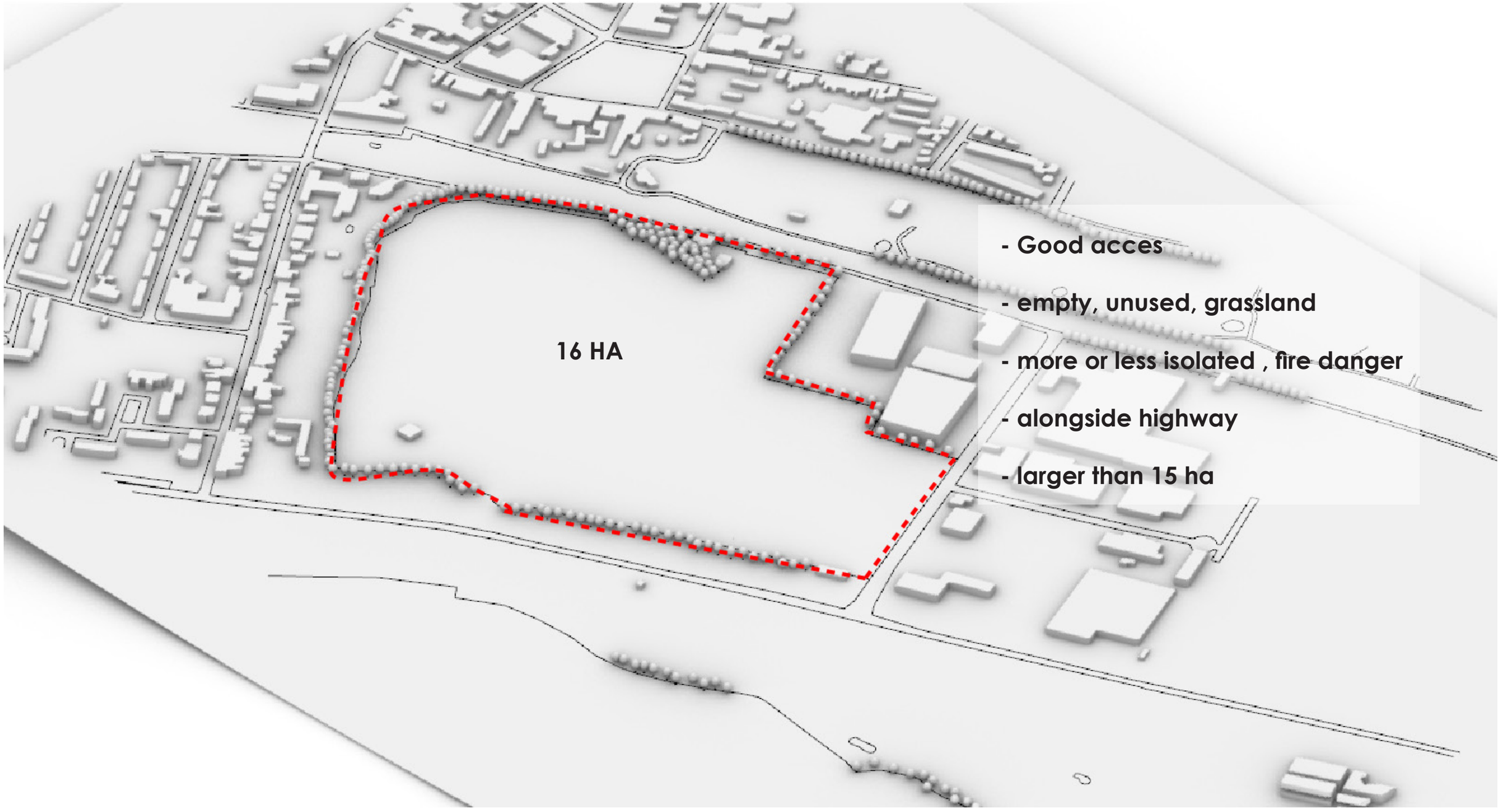
Flows & actors



Program


Info centre
400m2
Yoga / Sport
300m2
Cafe /
Restaurant
400m2
Laboratorium
700m2
Congress hall
700m2
Bio Digester
1200m2
Biorefinery
2400m2

Location requirements





Farmland



Wisosplit / Minestone Wilhelm Sophia

Current situation



Wisosplit



Grassland, former factory

Phasing

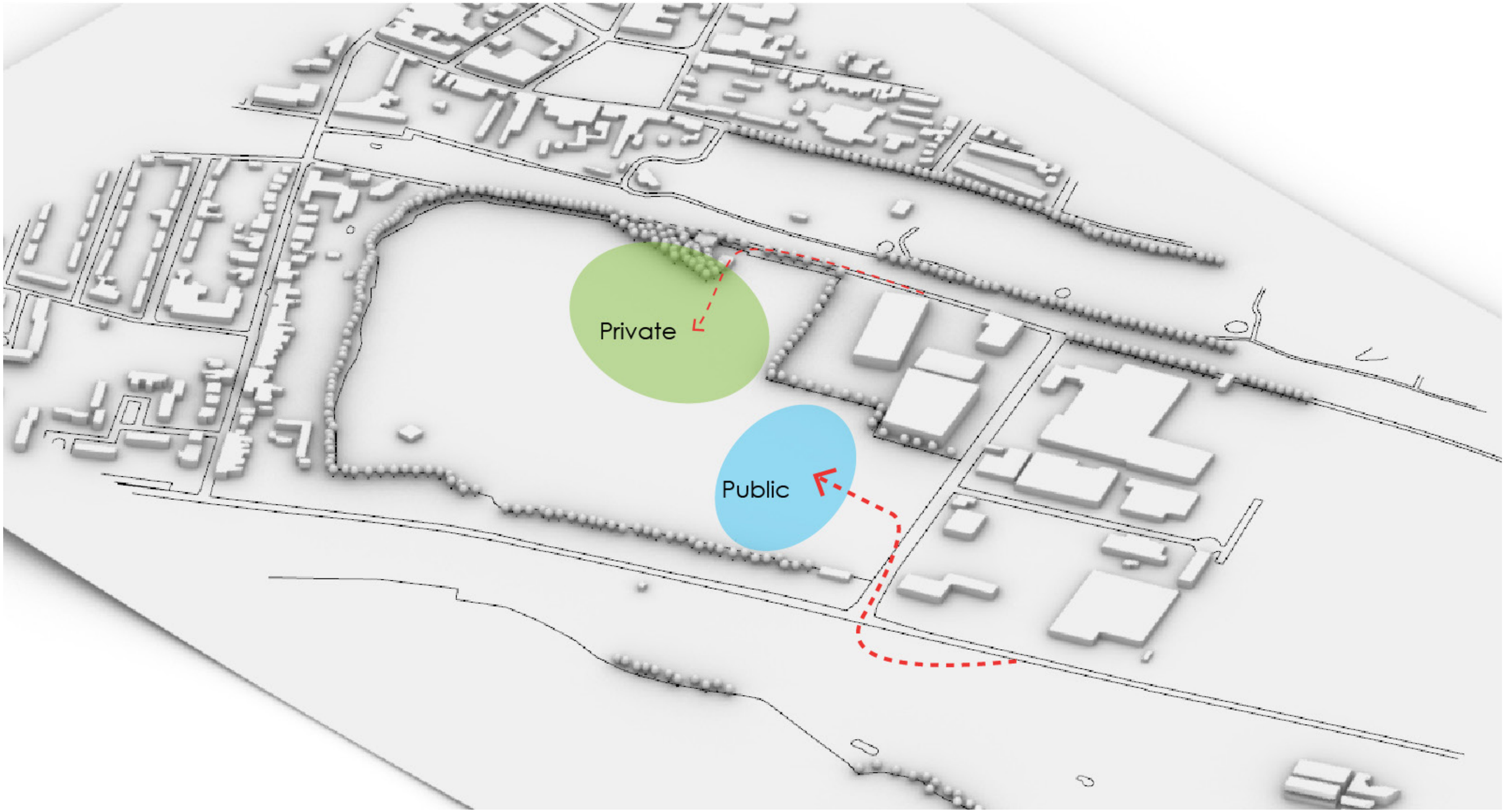


Phase I
1 ha, 2020

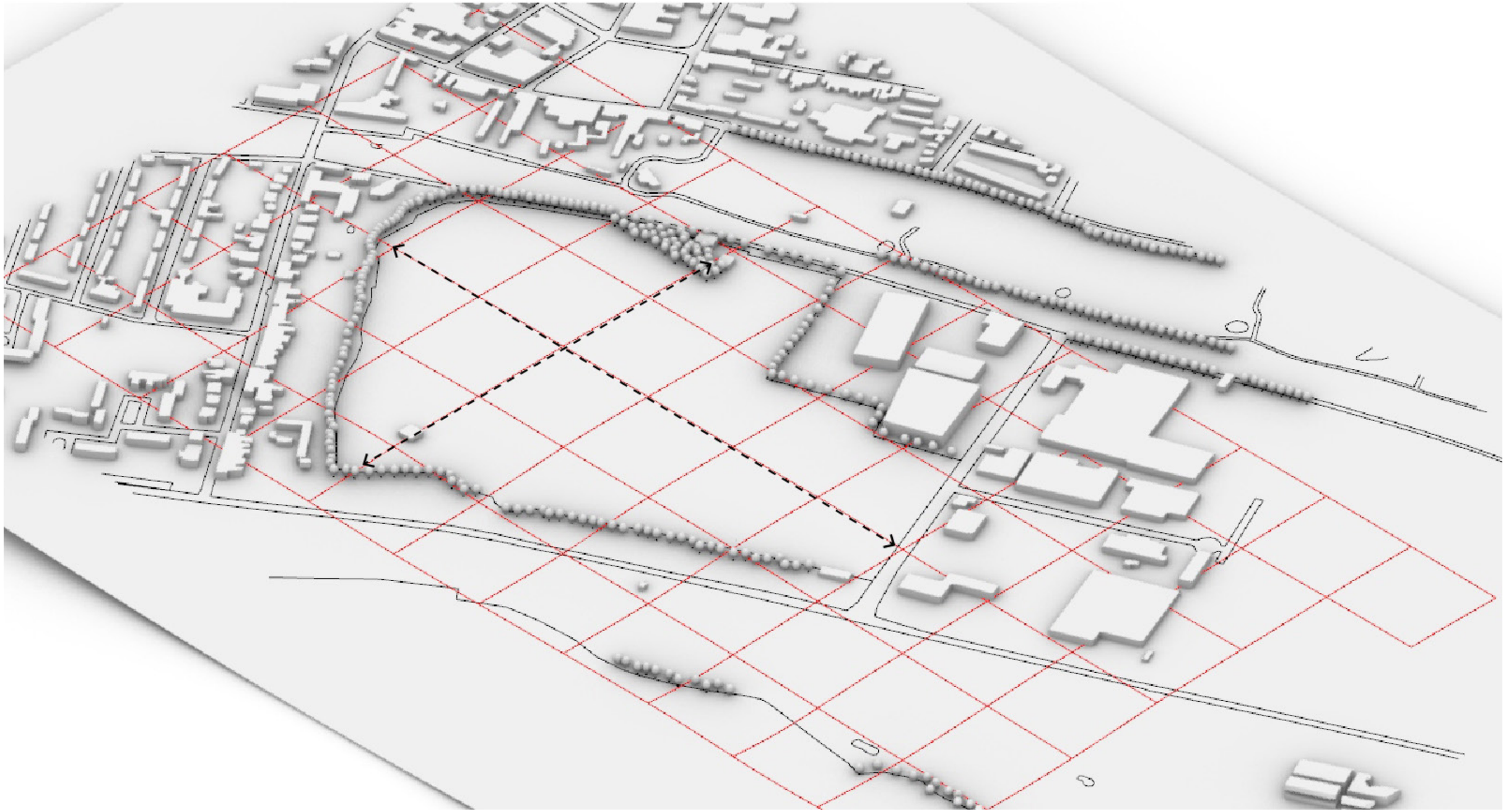


Phase II
15 ha, 2024

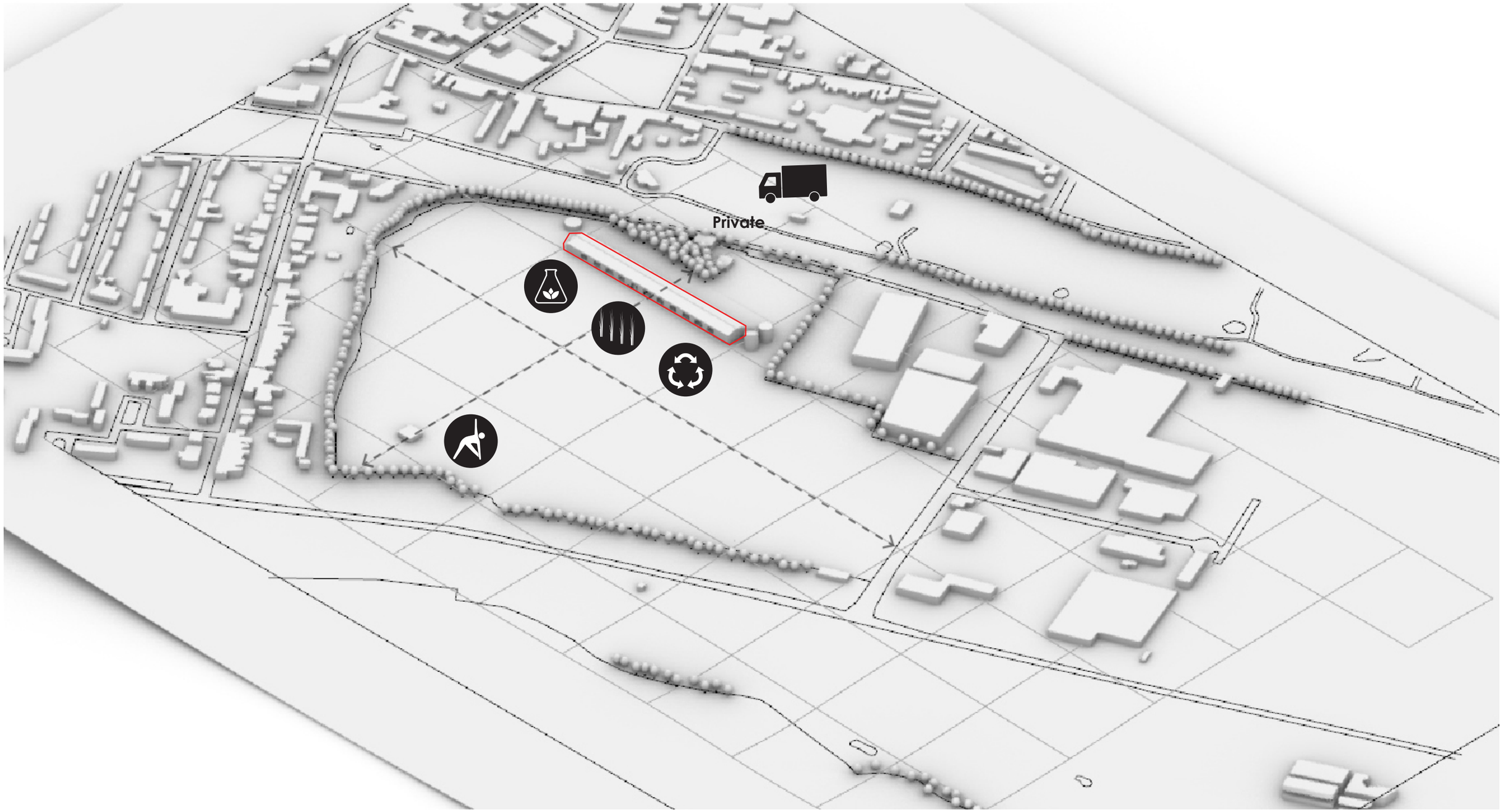
Site analysis



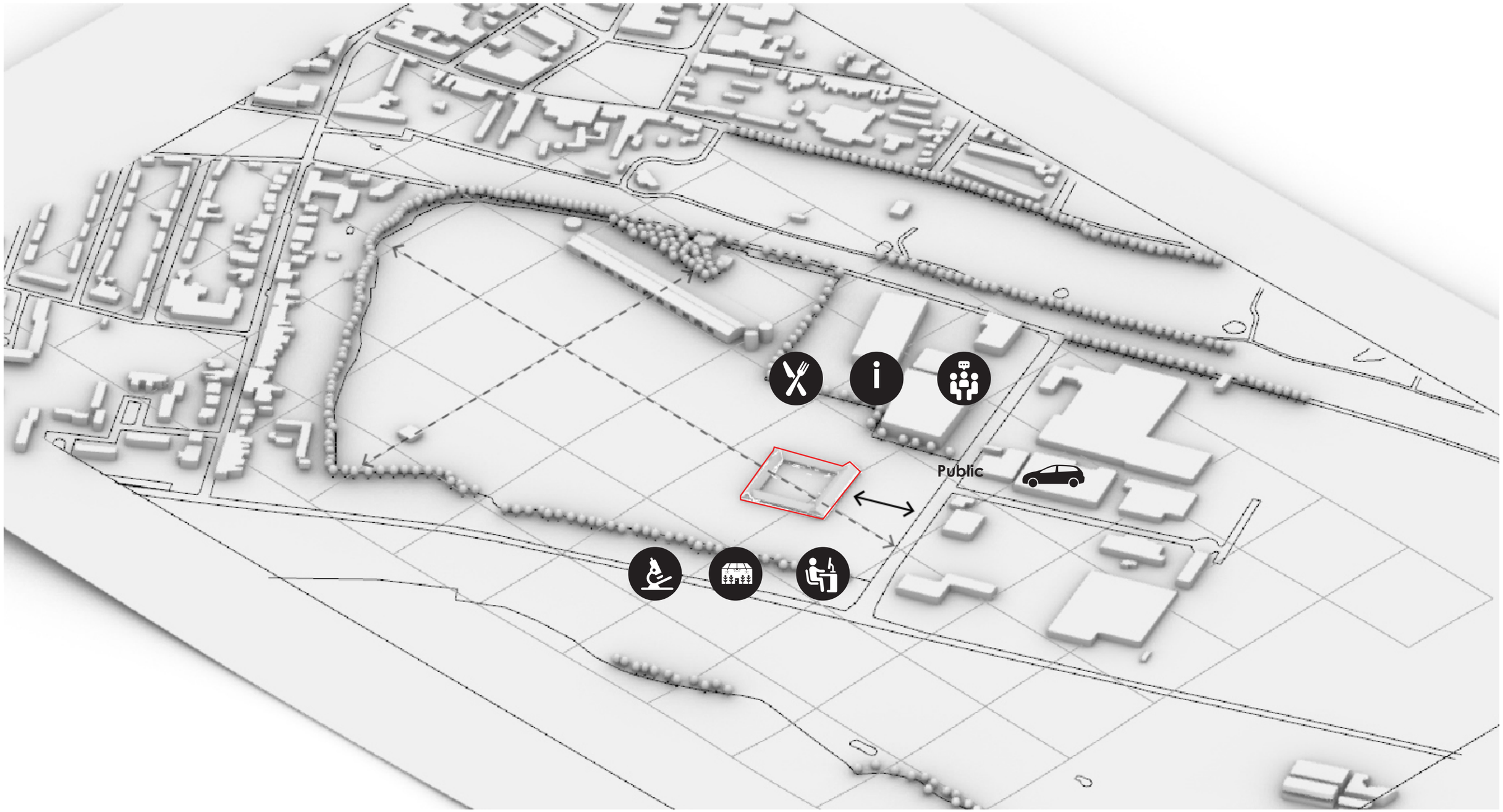
Grid & Axes



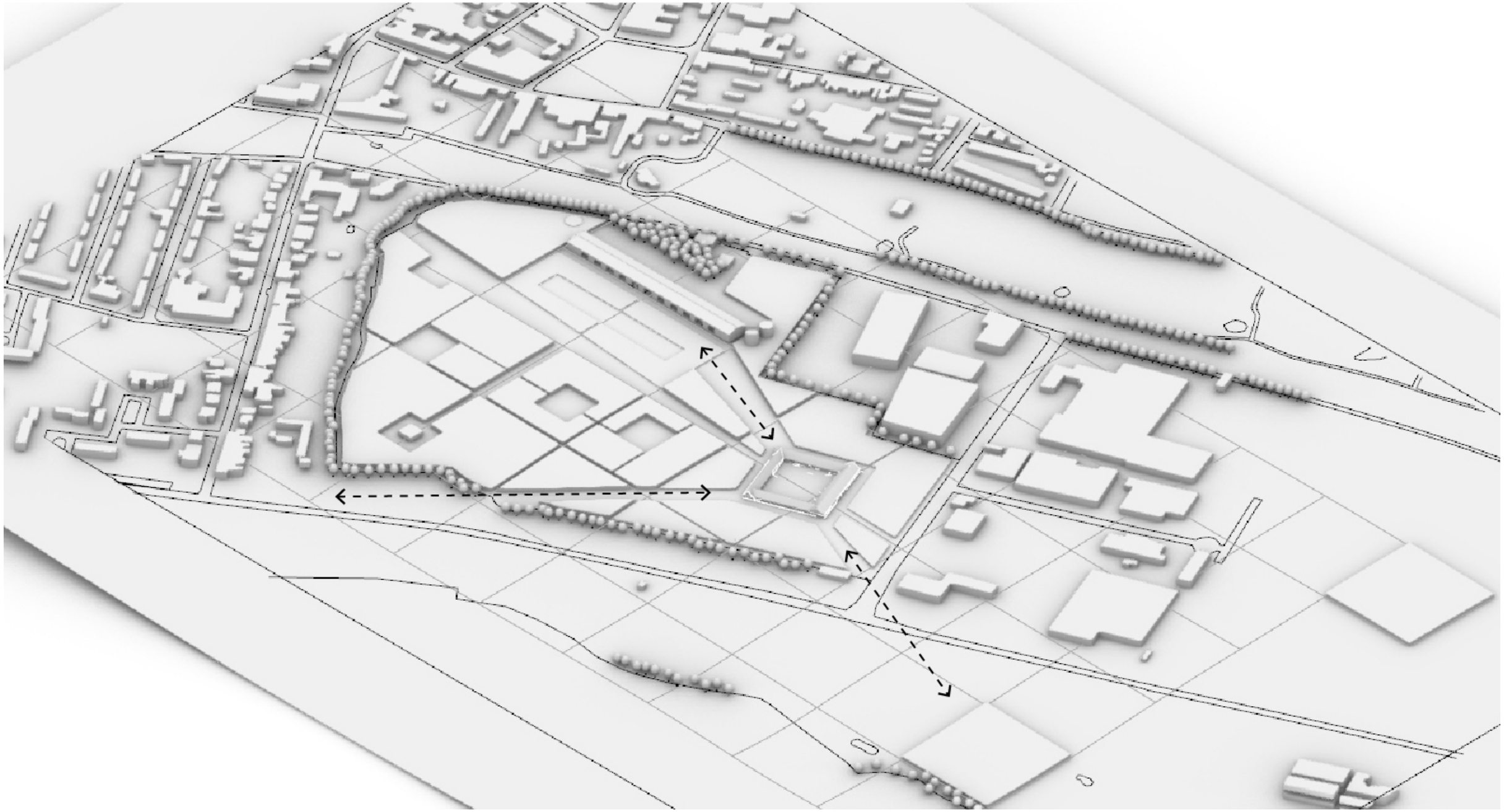
Factory



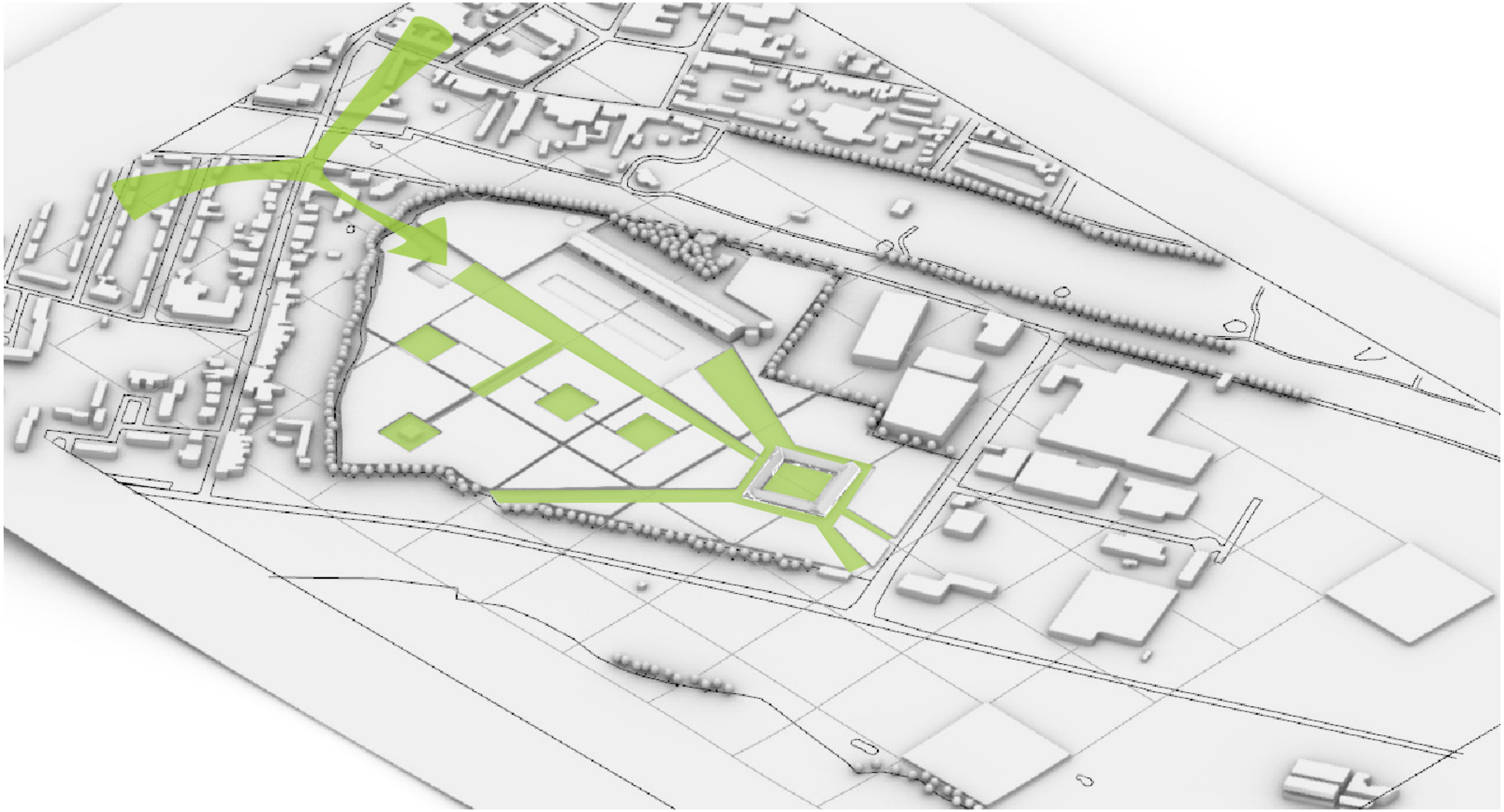
The Hoeve



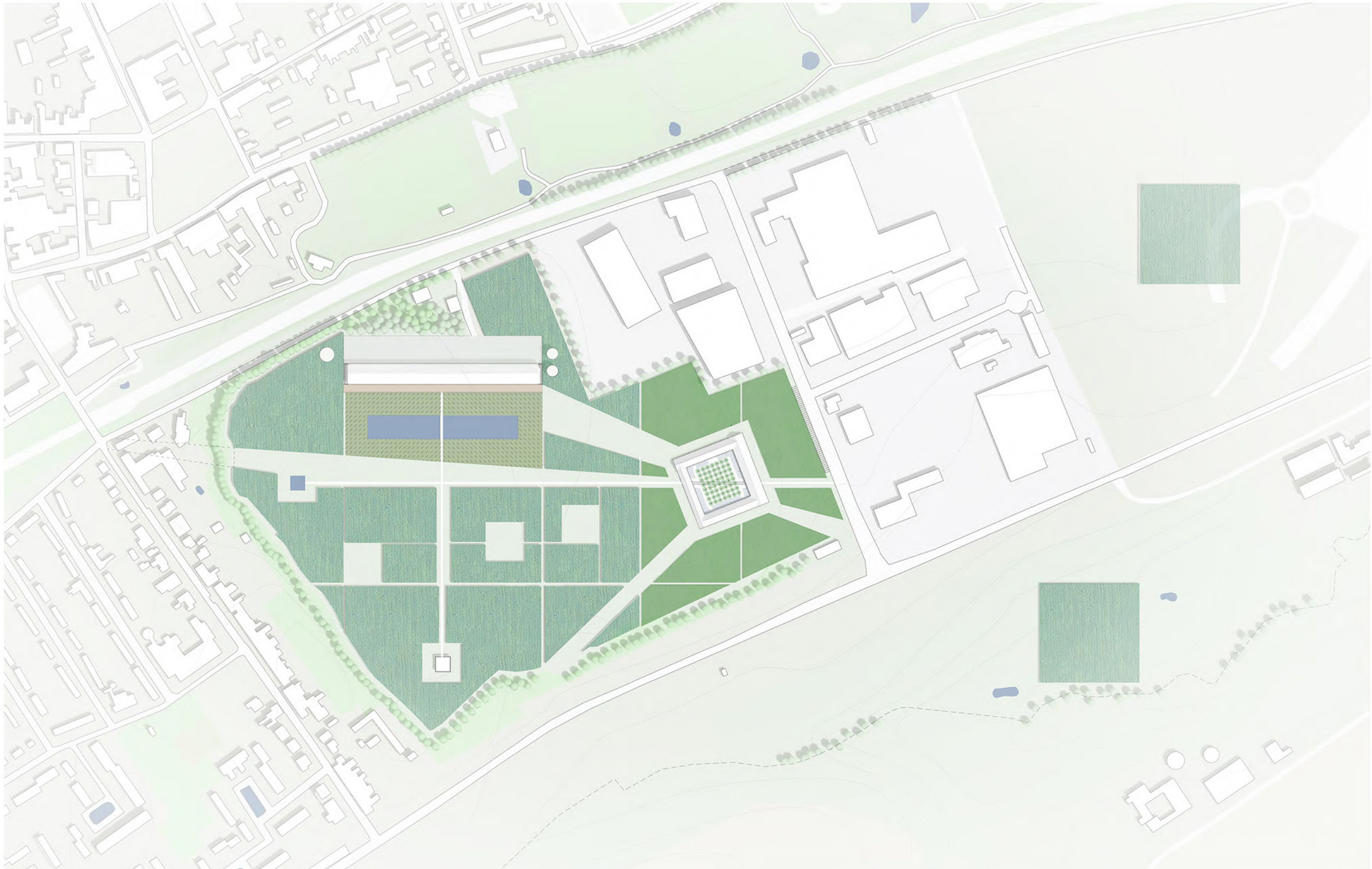
Sightlines



Public green

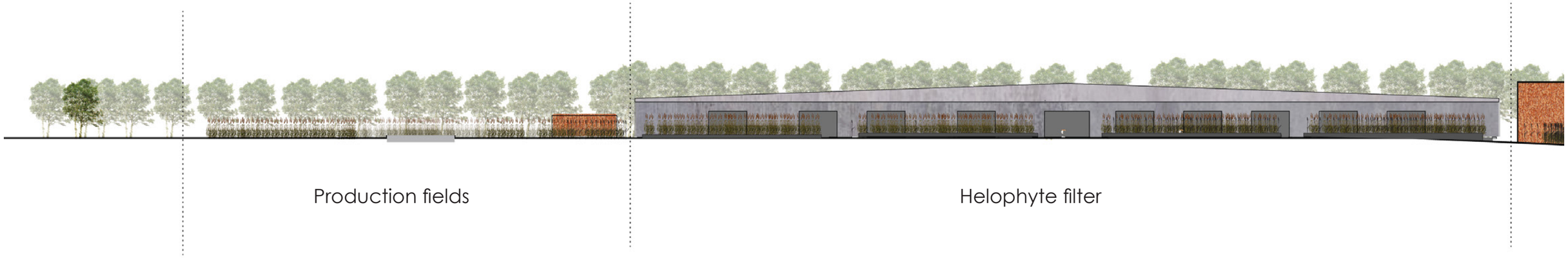


The plan



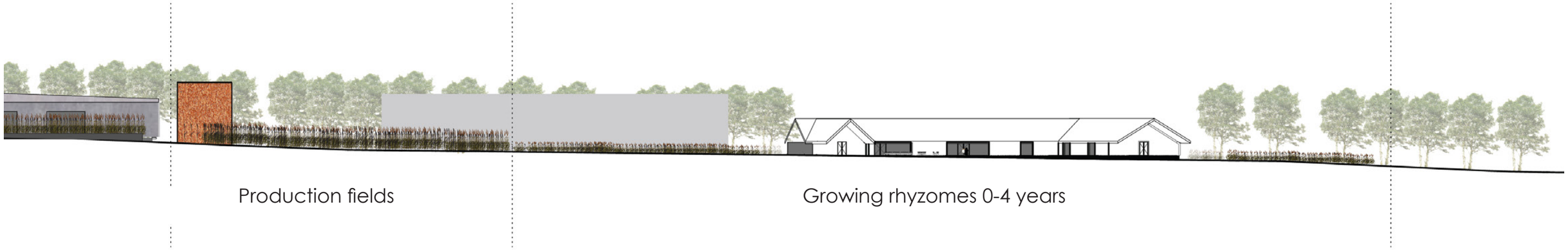
Scale : 1 / 2000

Section park



Production fields

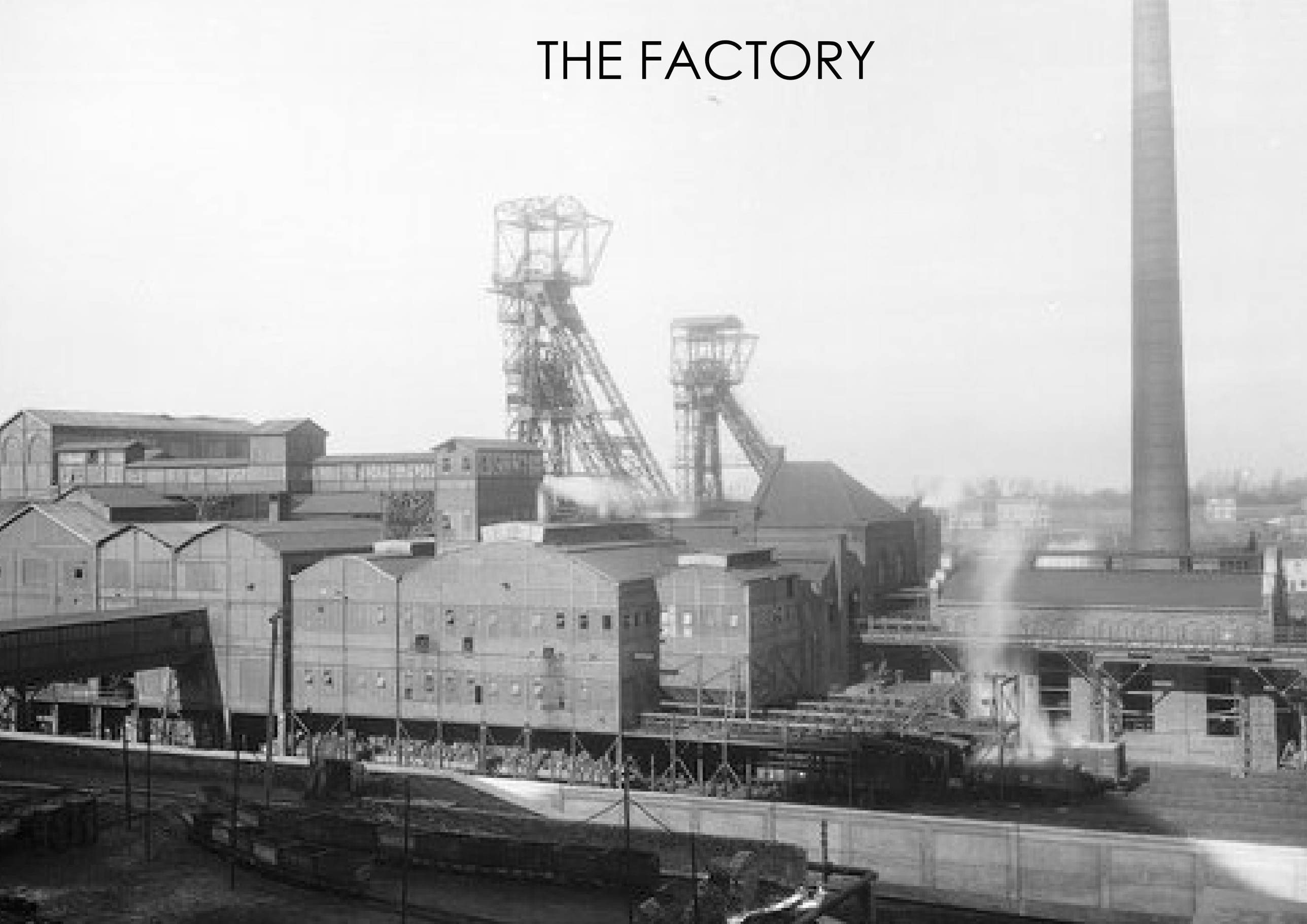
Helophyte filter



Production fields

Growing rhyzomes 0-4 years

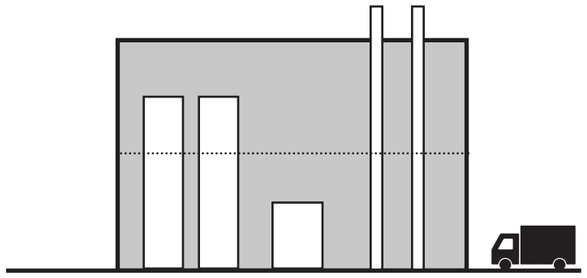
THE FACTORY



Scale



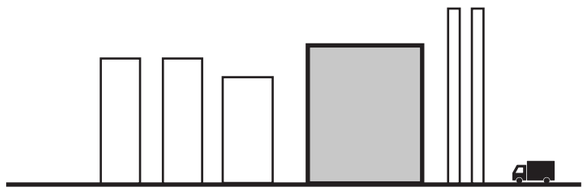
Sekab, Sweden



Small scale - demo plant

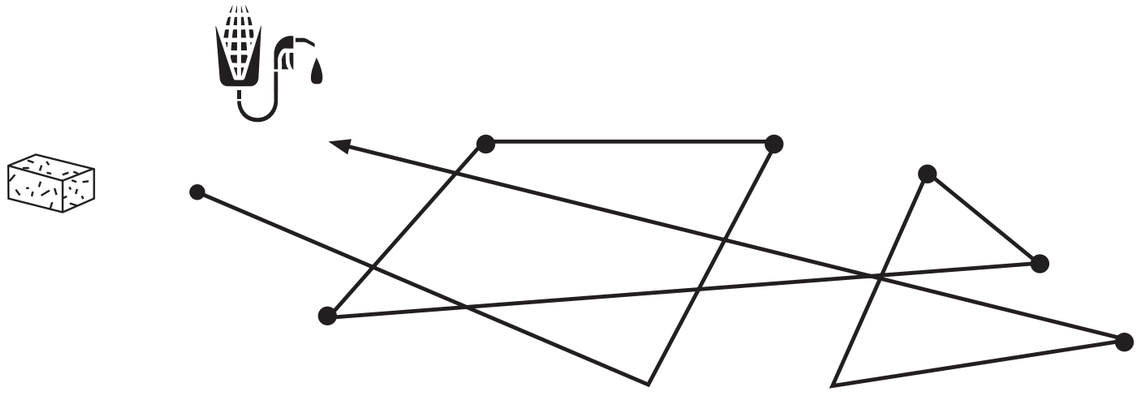


DSM / POET , Iowa USA

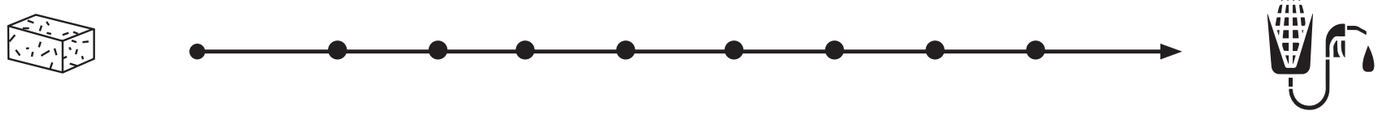


Large scale - industrial plant

Clustered versus linear

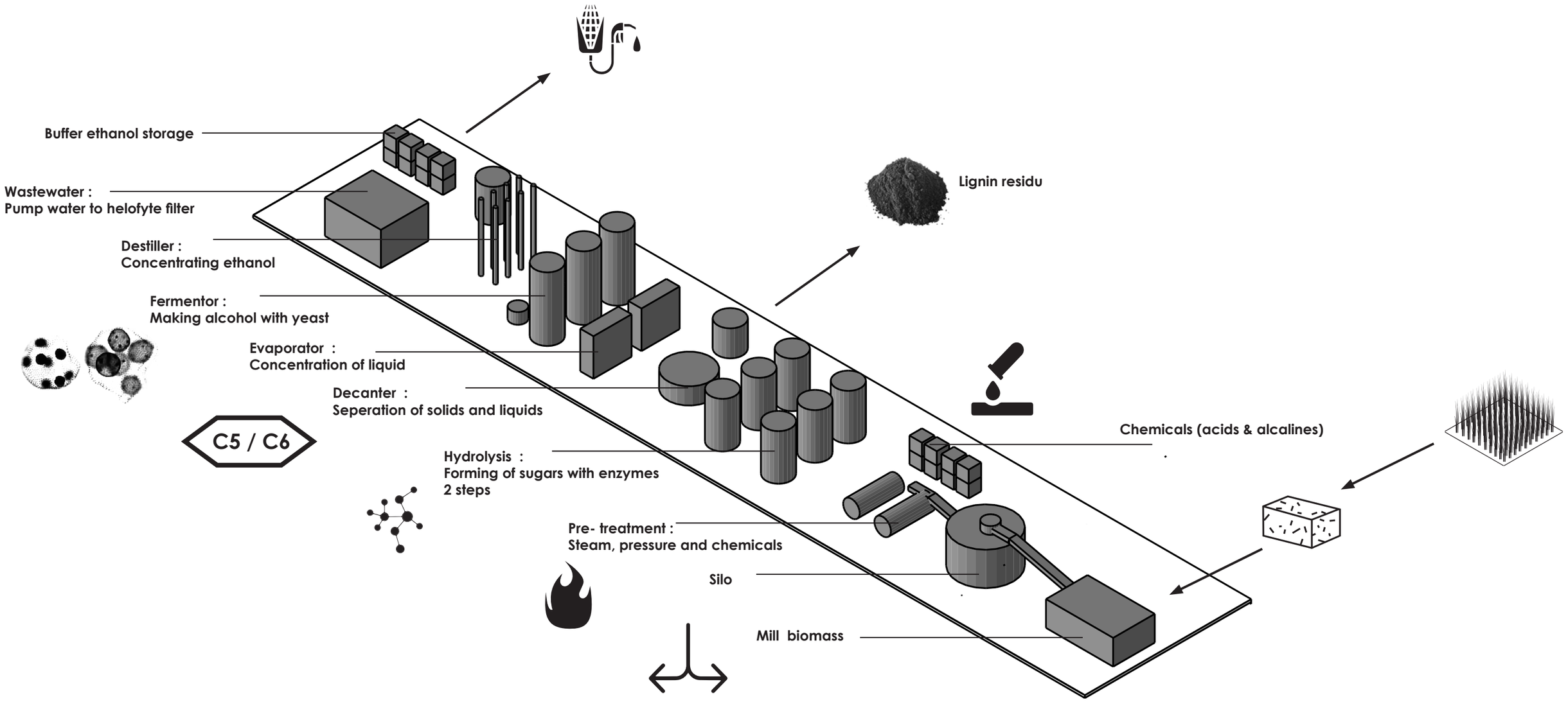






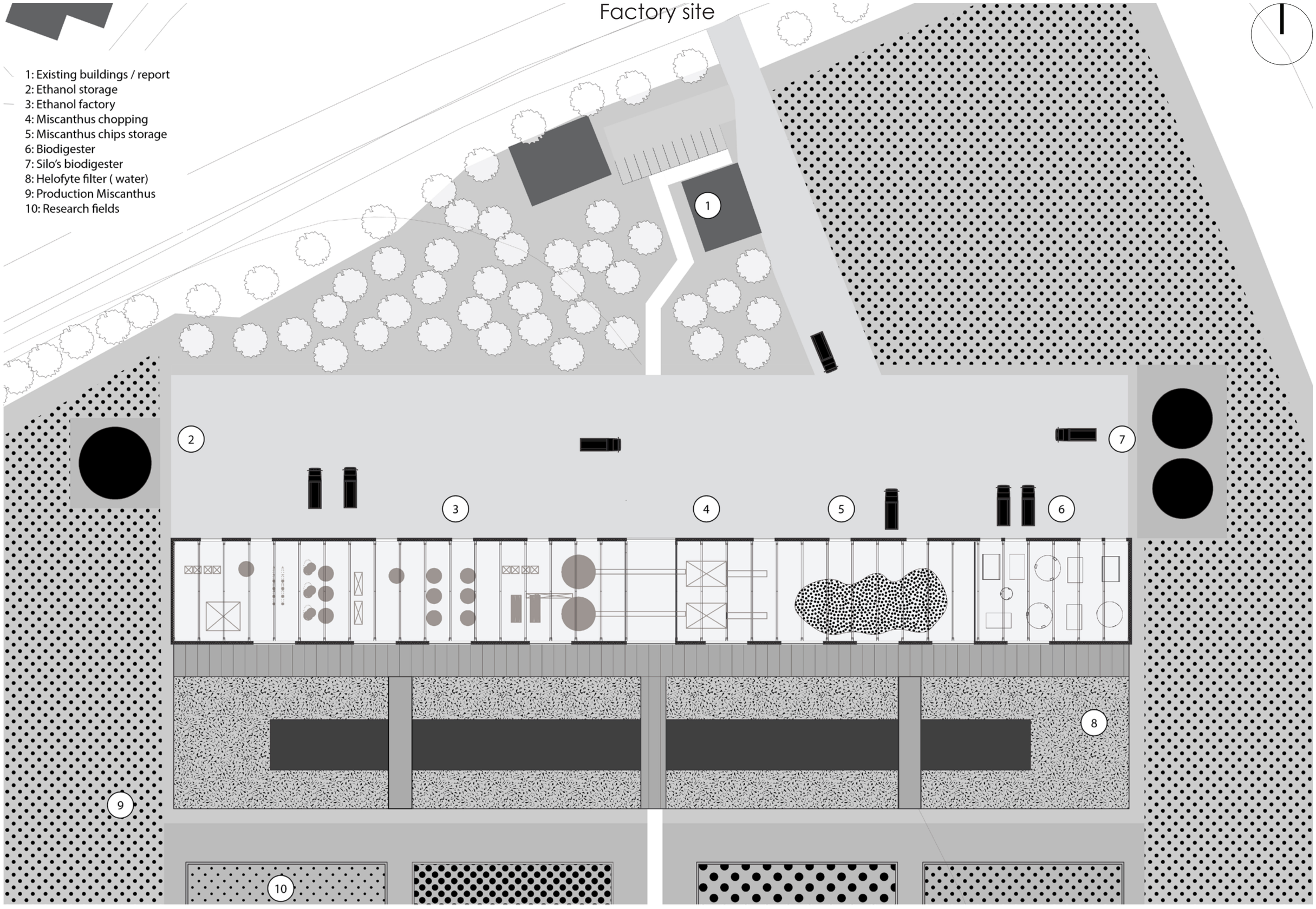


Processing Miscanthus

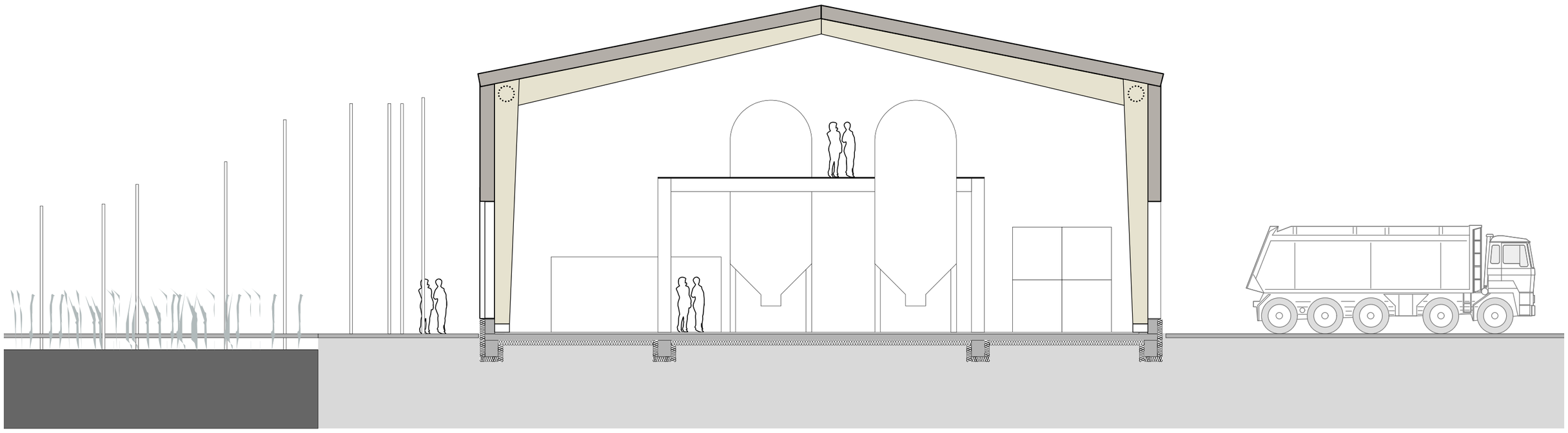


Factory site

1: Existing buildings / report
2: Ethanol storage
3: Ethanol factory
4: Miscanthus chopping
5: Miscanthus chips storage
6: Biodigester
7: Silo's biodigester
8: Helofyte filter (water)
9: Production Miscanthus
10: Research fields



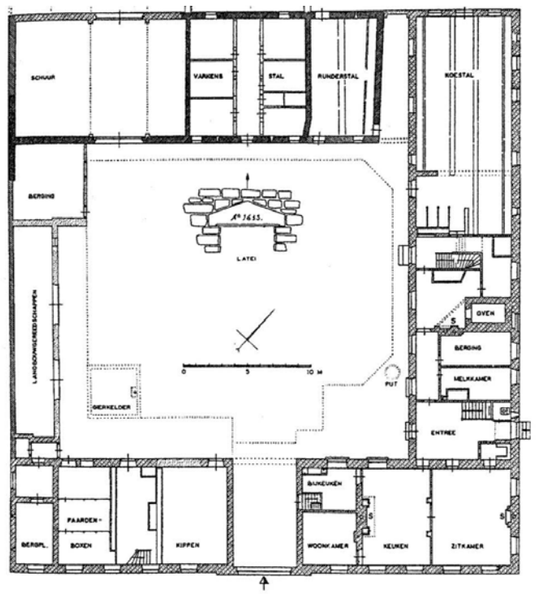
Factory site



THE HOEVE



Reference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VARKENS
STAL
RUNDERSTAL
ROCSTAL
BERGING
LANDBOUWGEREEDSCHAPPEN
A° 1665.
LATEI
GIERKELDER
PUT
0 5 10 M
OVEN
BERGING
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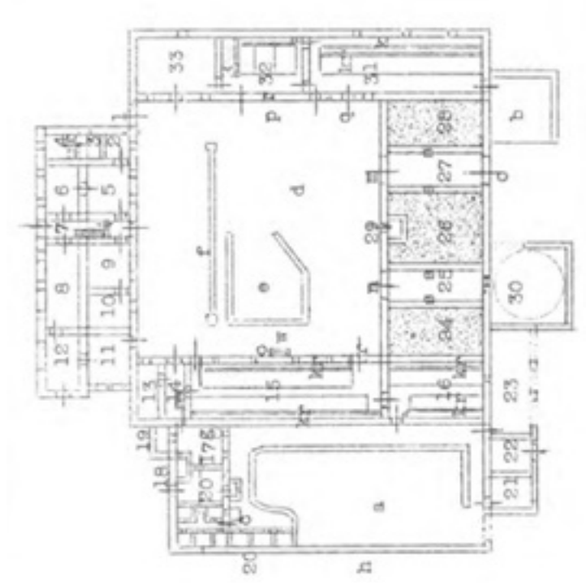
PAARDEN-
BOXEN
KIPPEN
BAKOVEN
WOONKAMER
KEUKEN
ZITKAMER

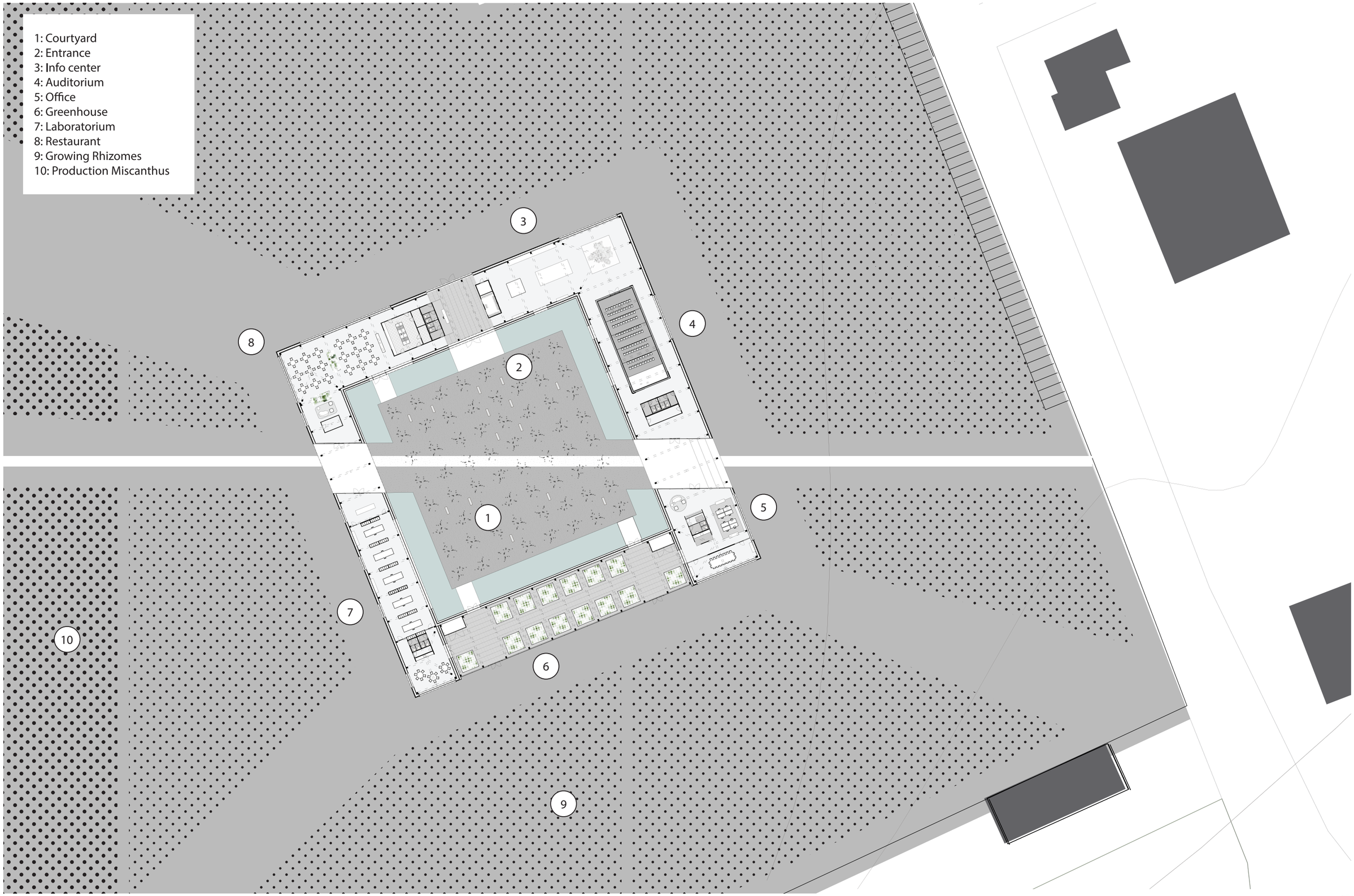






Hoeve site

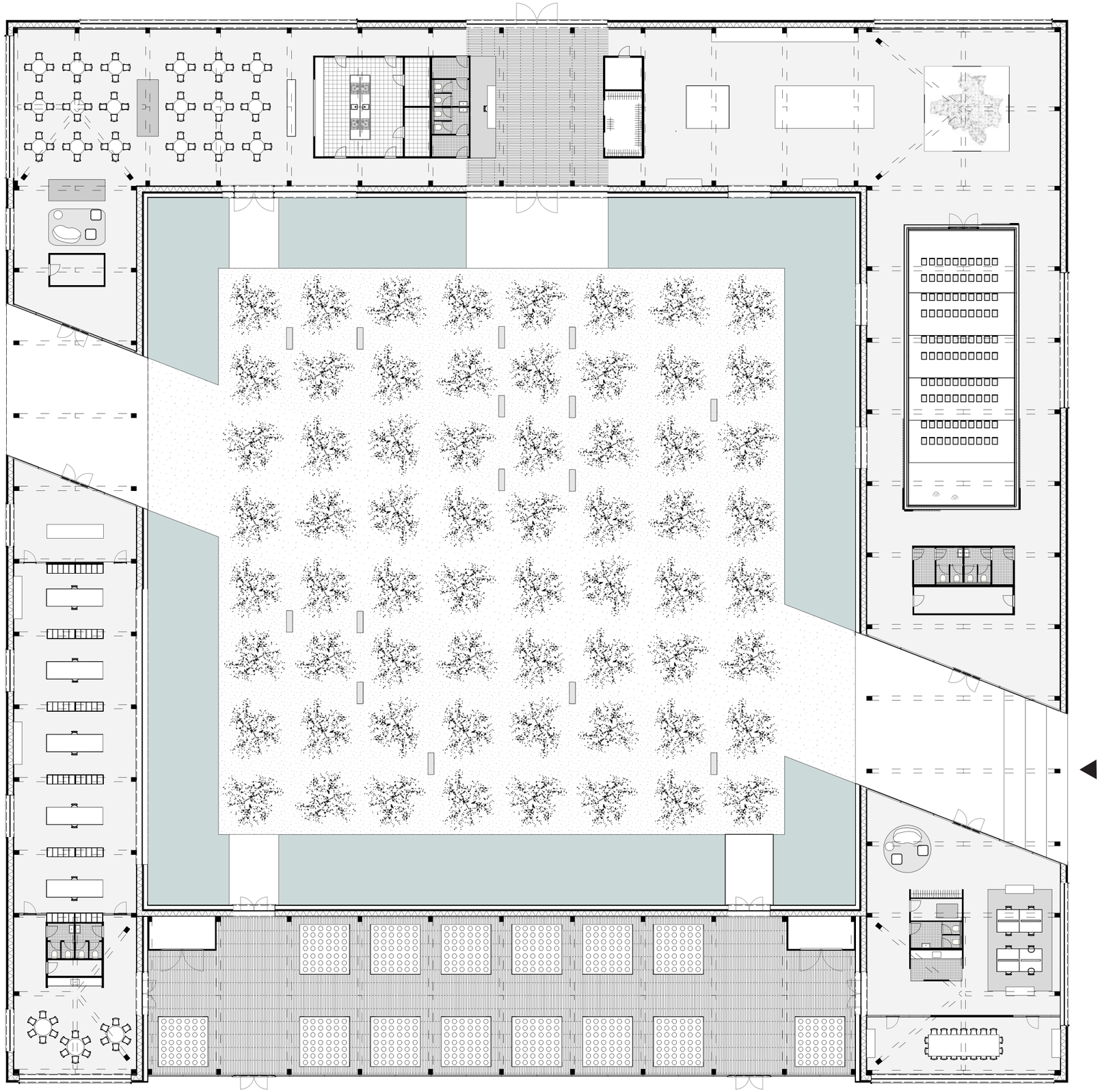
1: Courtyard
2: Entrance
3: Info center
4: Auditorium
5: Office
6: Greenhouse
7: Laboratorium
8: Restaurant
9: Growing Rhizomes
10: Production Miscanthus



The Hoeve

Scale : 1 / 500

Hoeve plan



Facade materials

Exterior



Xiriton - lightweight concrete with Miscanthus



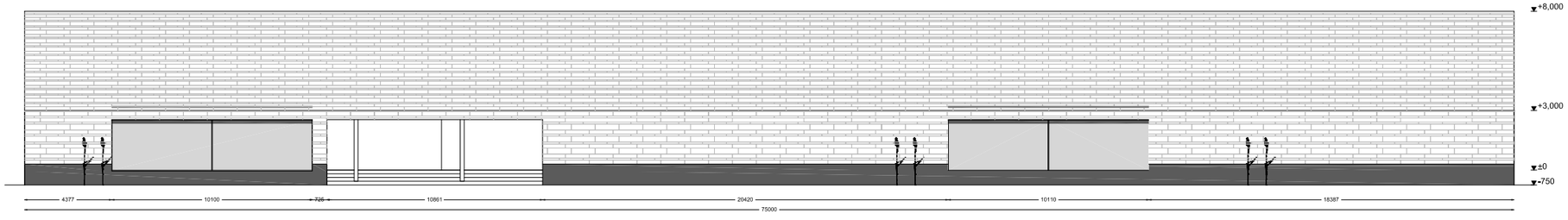
Panels 1200x400x50 mm

Courtyard

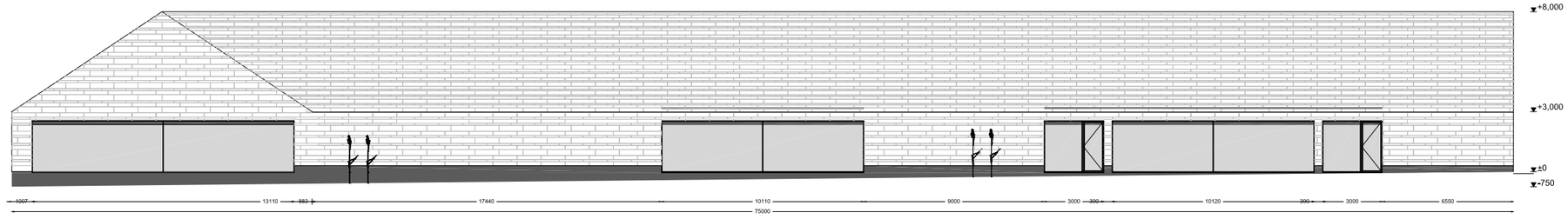


Miscanthus

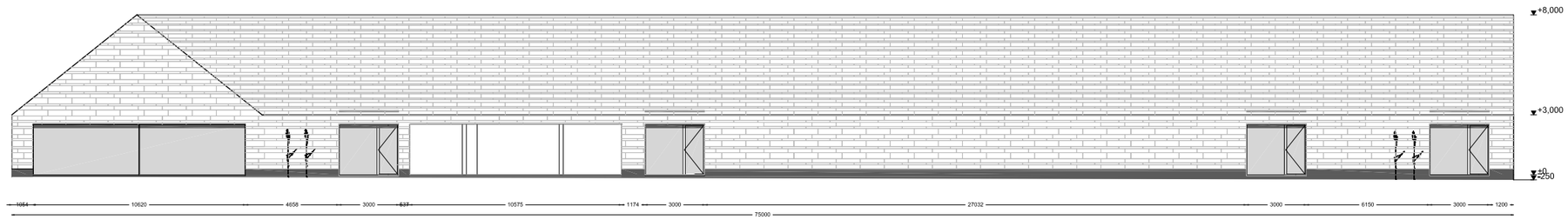
Facade



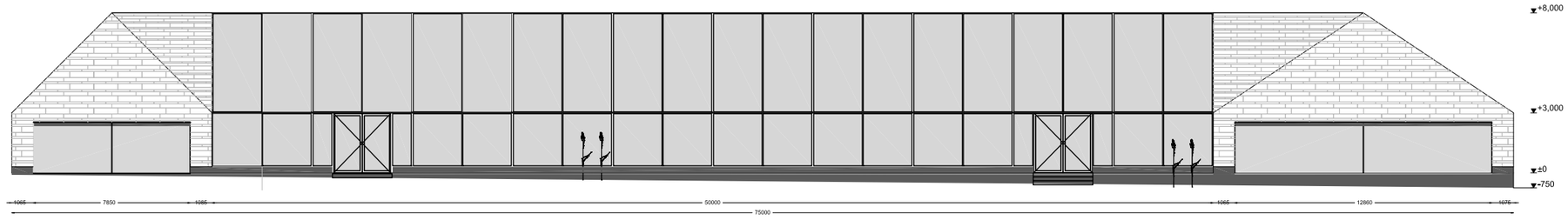
EAST FACADE EXTERIOR



NORTH FACADE EXTERIOR

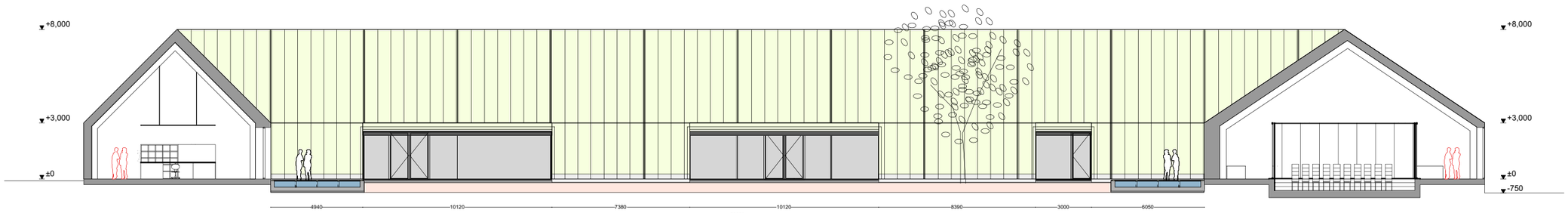


WEST FACADE EXTERIOR



SOUTH FACADE EXTERIOR

Section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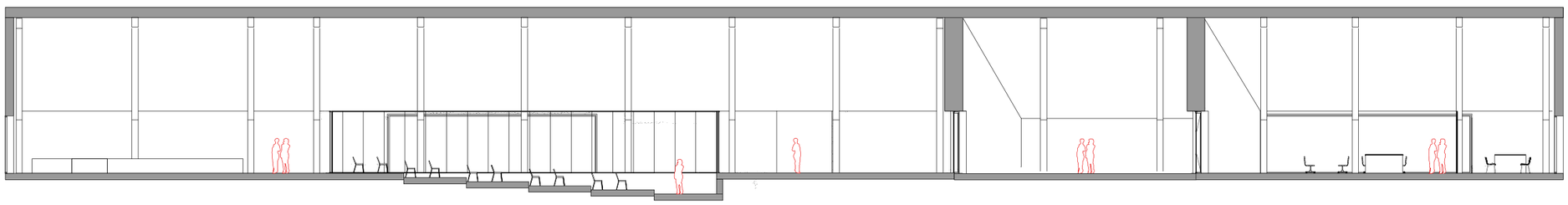
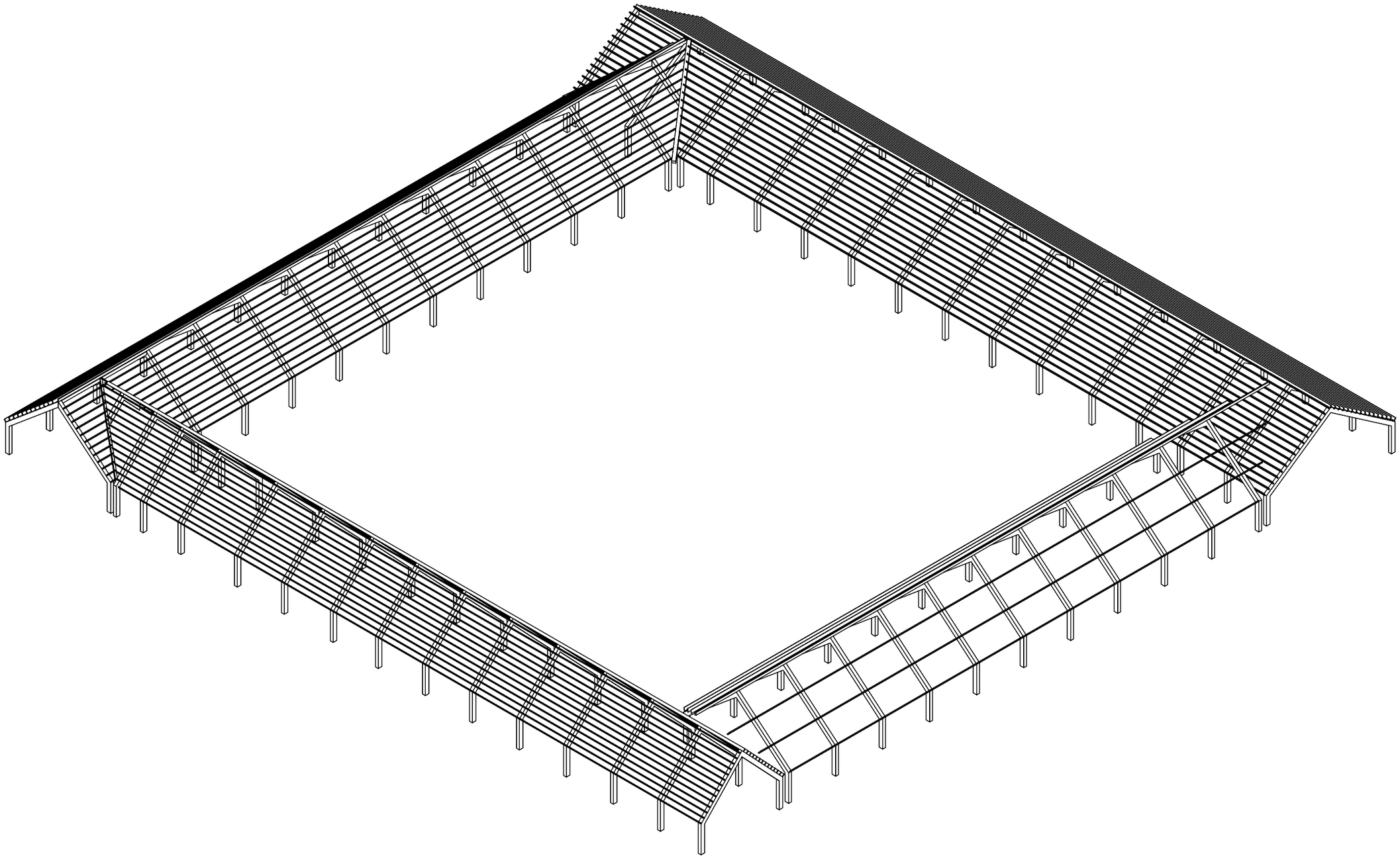
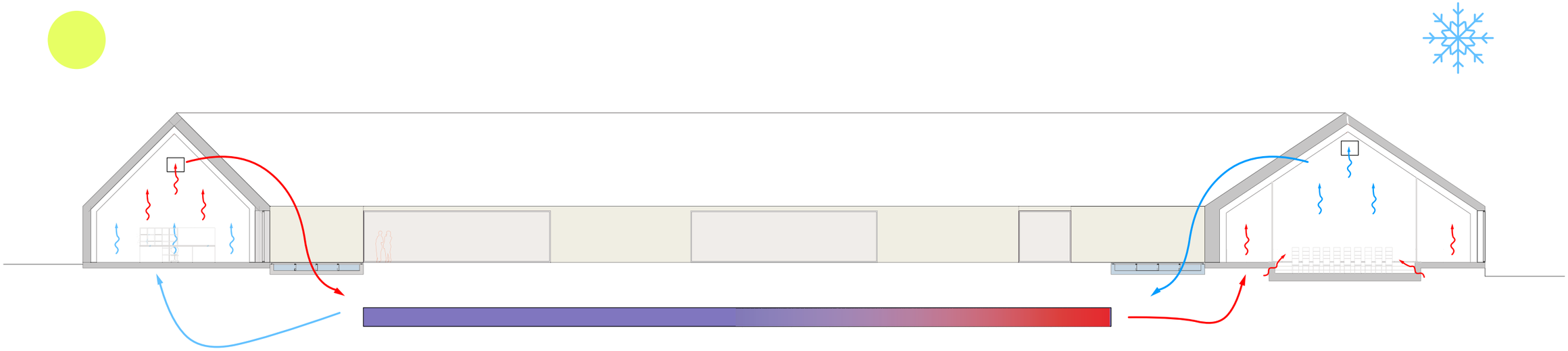


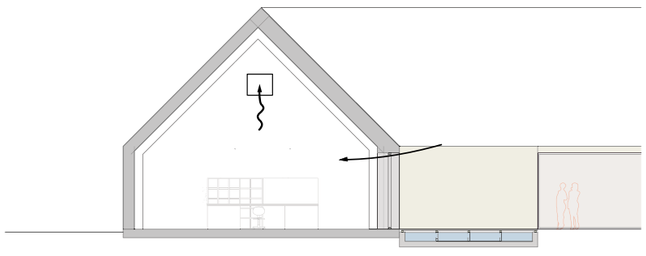
Construction



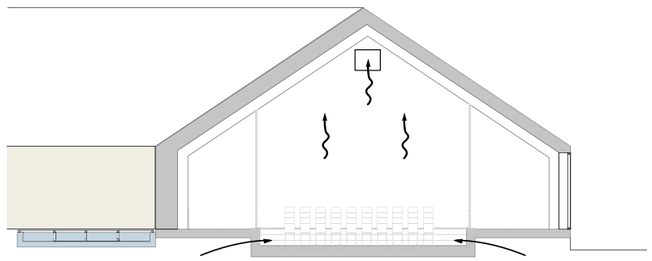
Building physics



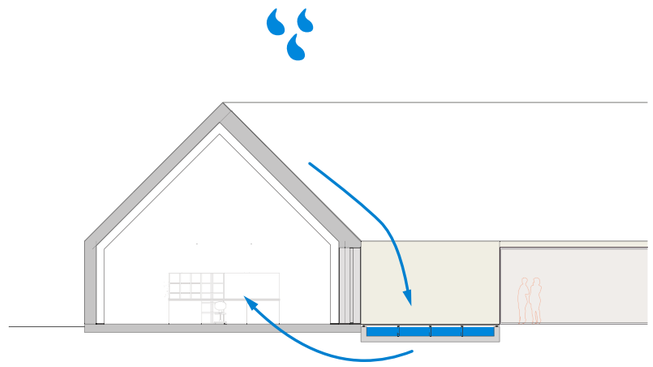
Scale : 1 /200
Heating
Groundheat exchange



Scale : 1 /200
Type I
Ventilation
Natural supply
Mechanical exhaust



Scale : 1 /200
Type II/ III
Ventilation
Mechanical supply
Mechanical exhaust

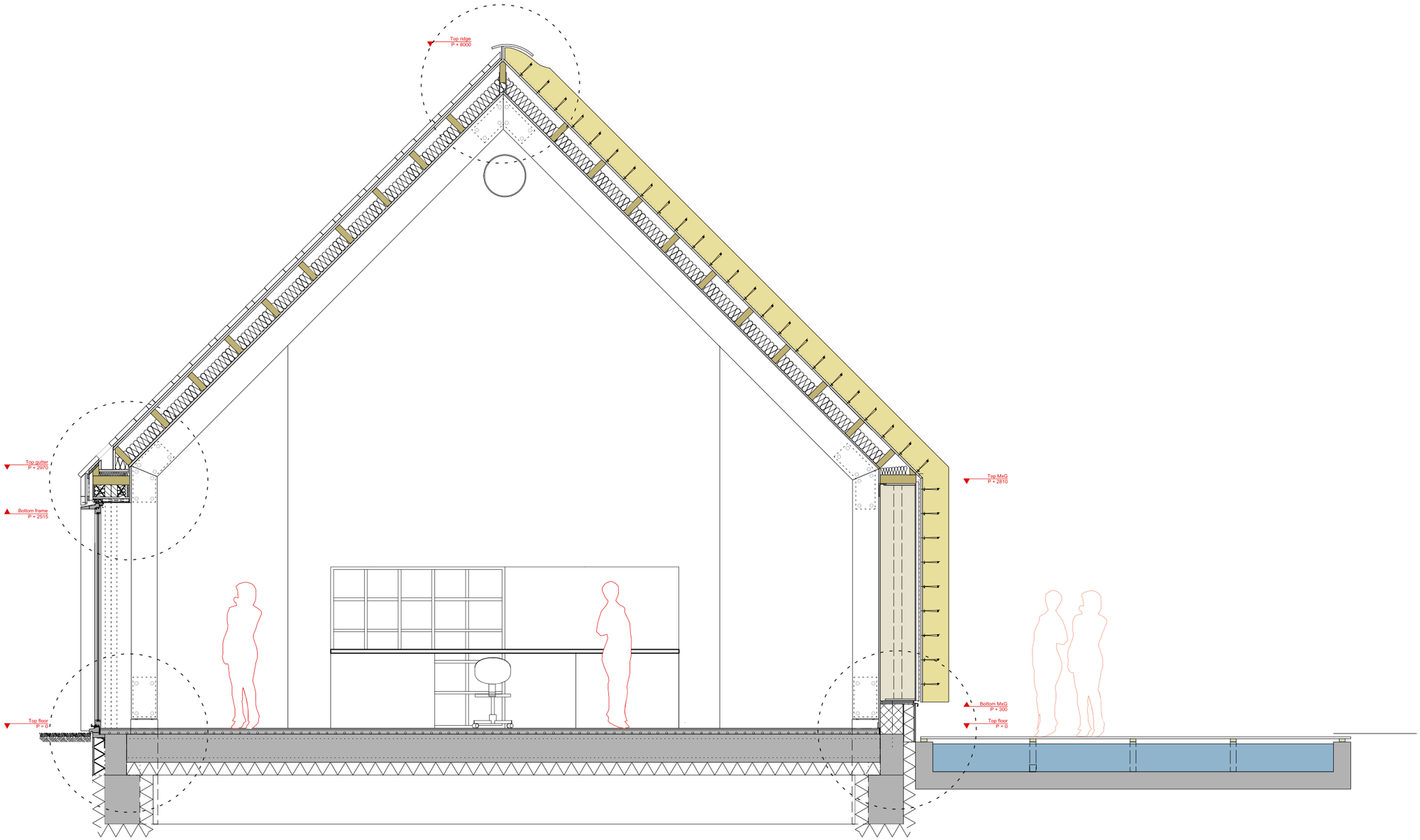


Scale : 1 /200
Rain Water storage
Grey water system toilets

Straw block system



Section Lab

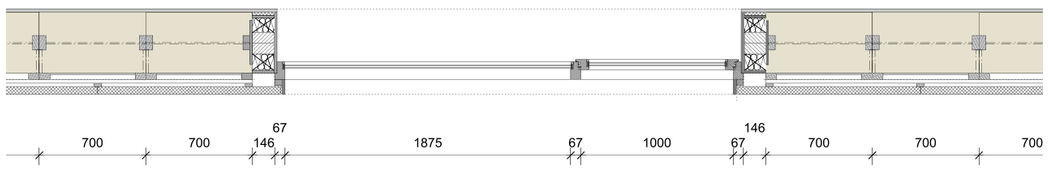


Section 1:50

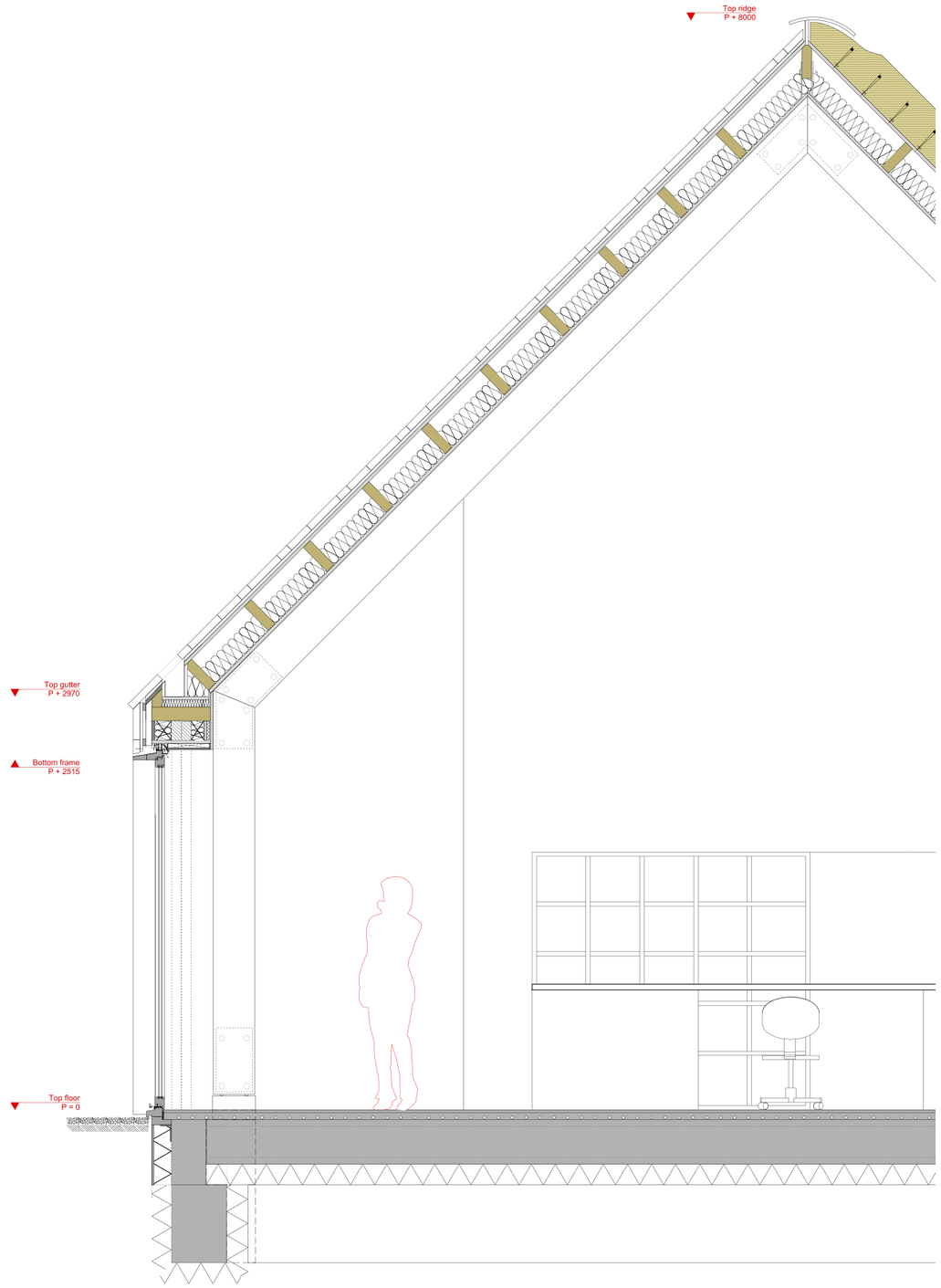
Facade



Facade Scale : 1 / 20

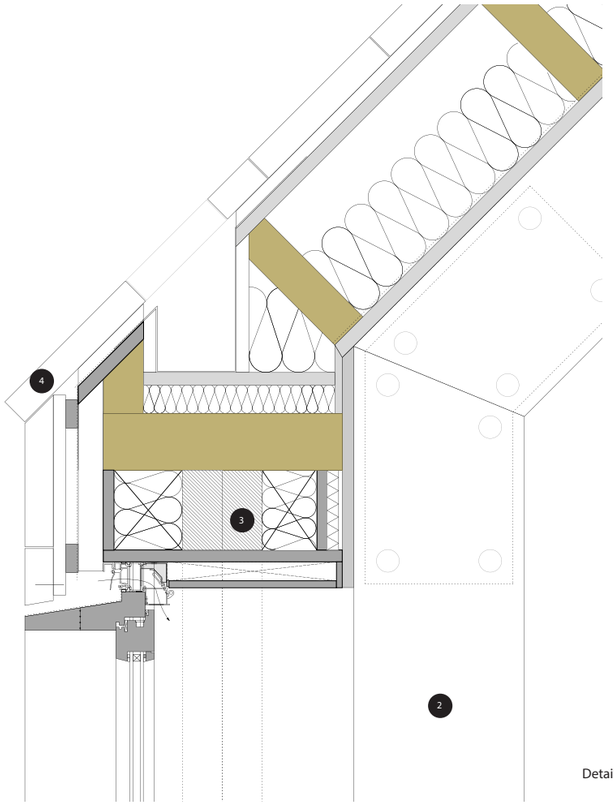


Plan Scale : 1 / 20

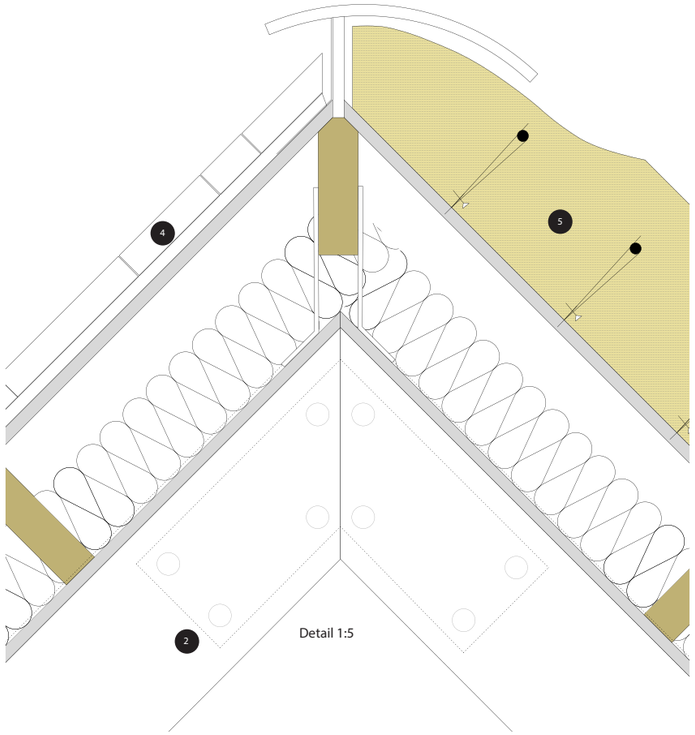


Section Scale : 1 / 20

Detail



Detail 1:5



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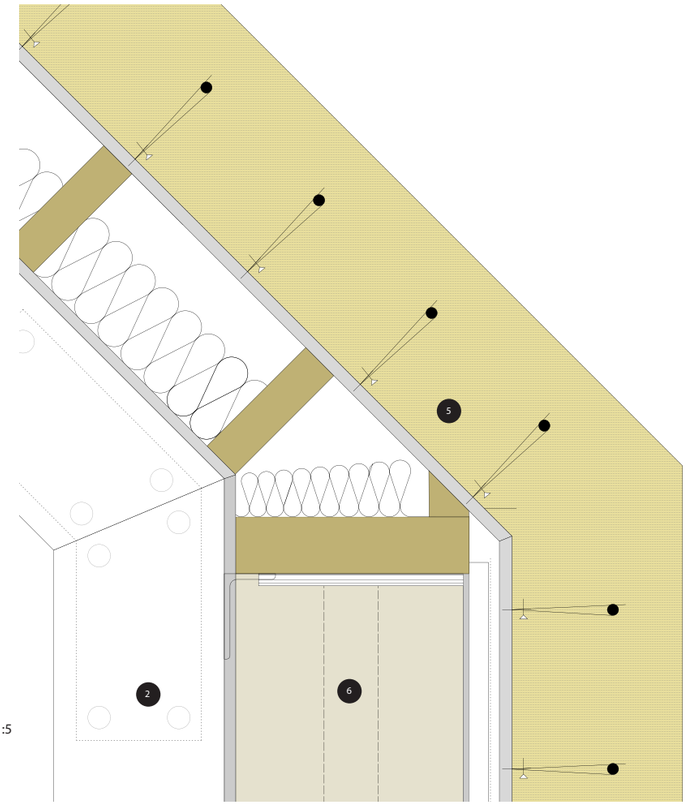
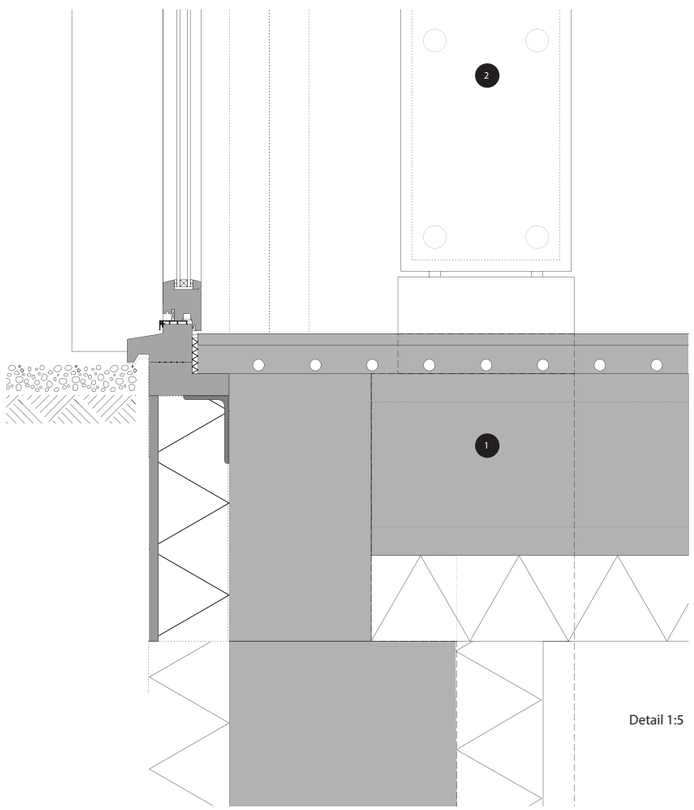
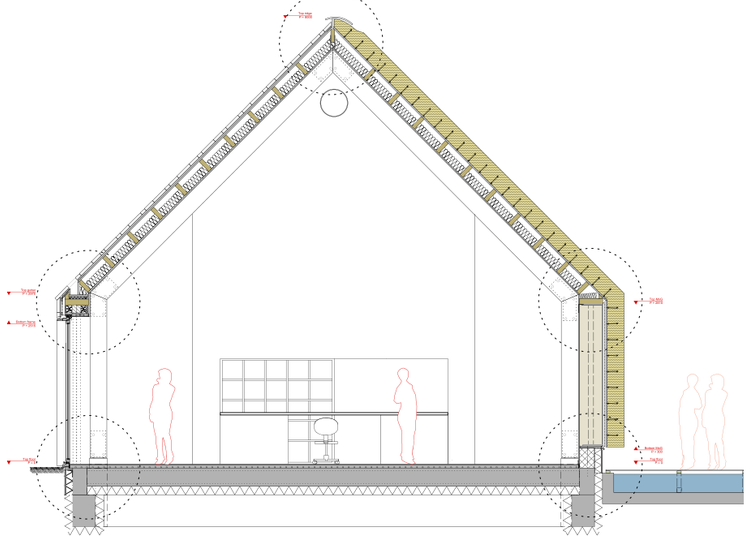


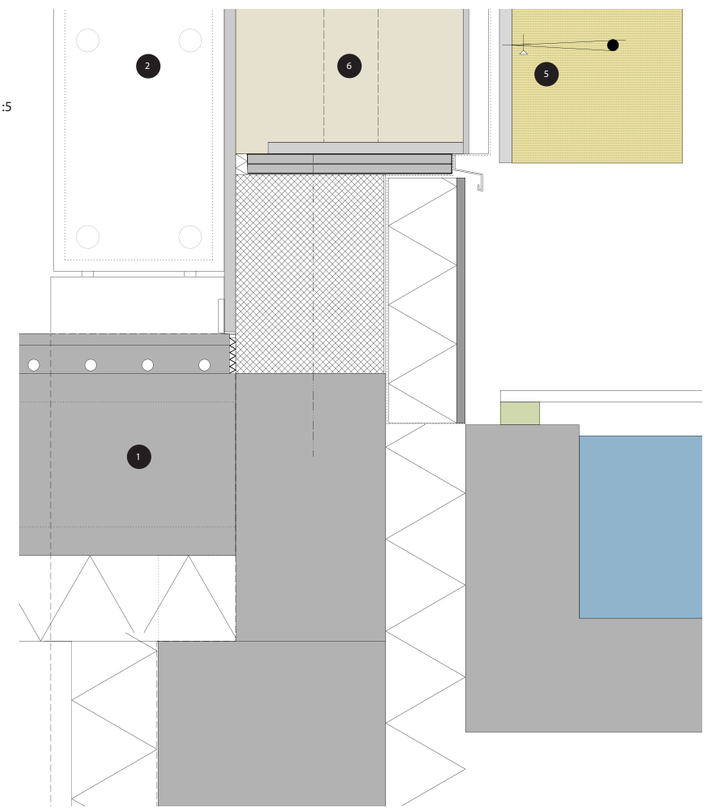
Detail 1:5



Detail 1:5



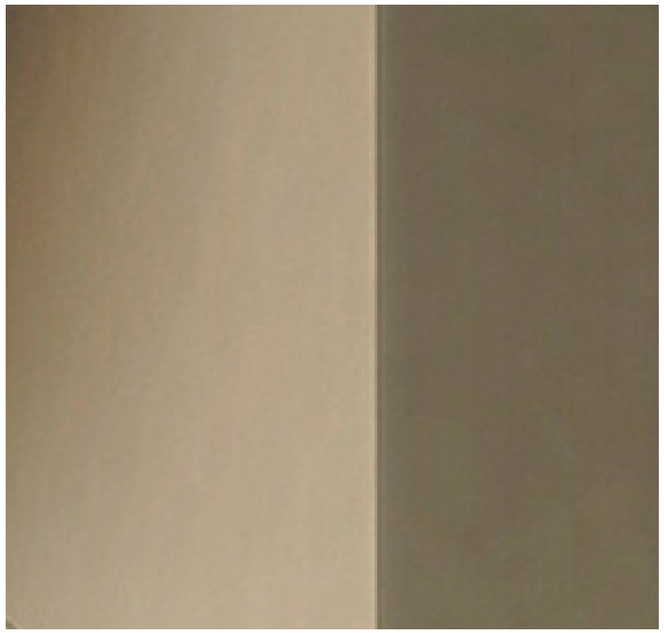
Section 1:50



Detail 1:5

1: Hollow core floor slab 320 mm
2: Kerto Truss 300x150mm
3: Wooden lintel 2x 140x70mm
4: Xiriton stone 1200x400x50mm
5: Miscanthus x Giganteus 300mm
6: MxG wall element 700x400 Rc > 6 m2 K / W

Interior finishing



Walls & ceiling
loam (clay) stucco
(white)

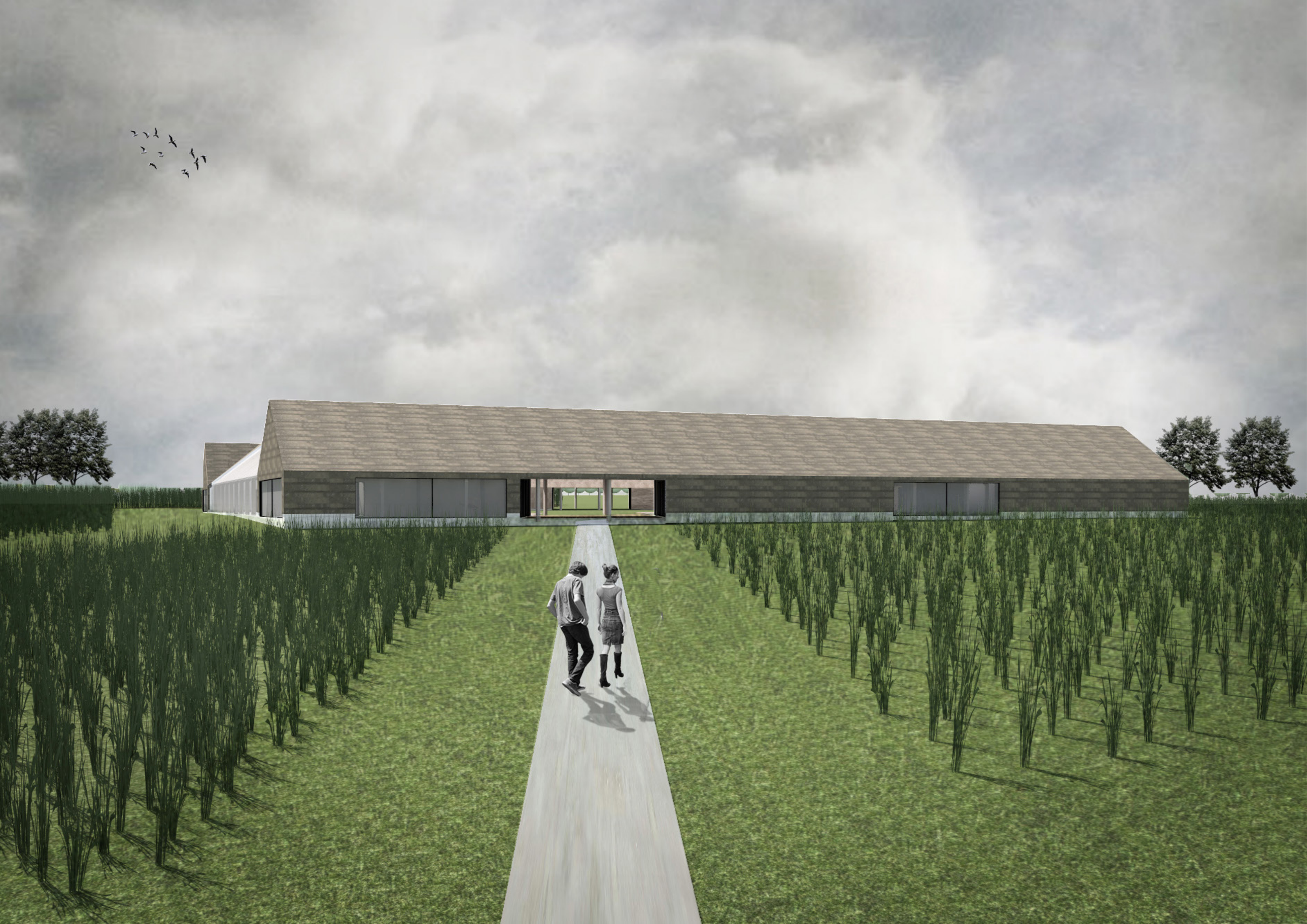


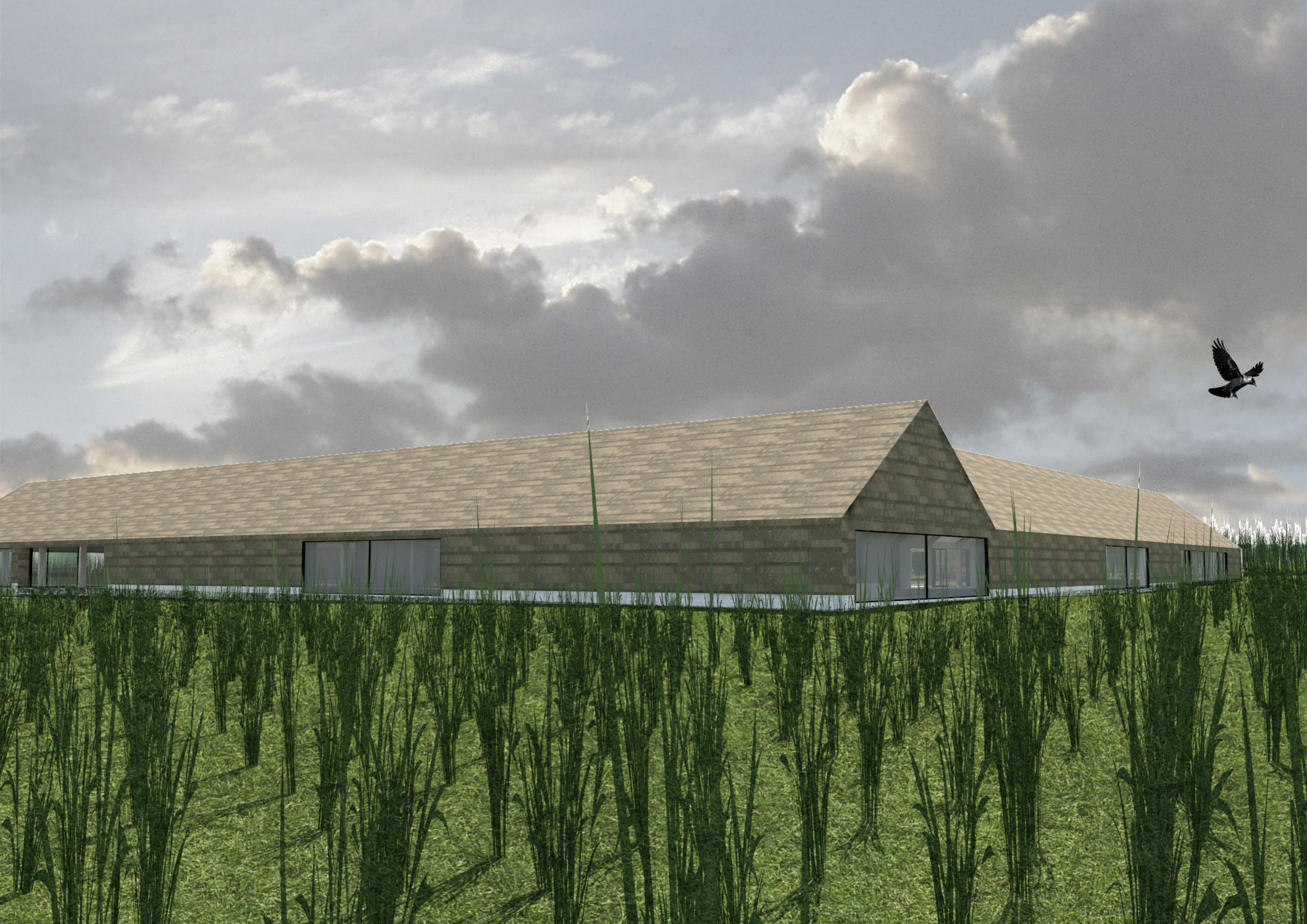
Floors
polished concrete finish floor
(dark grey)



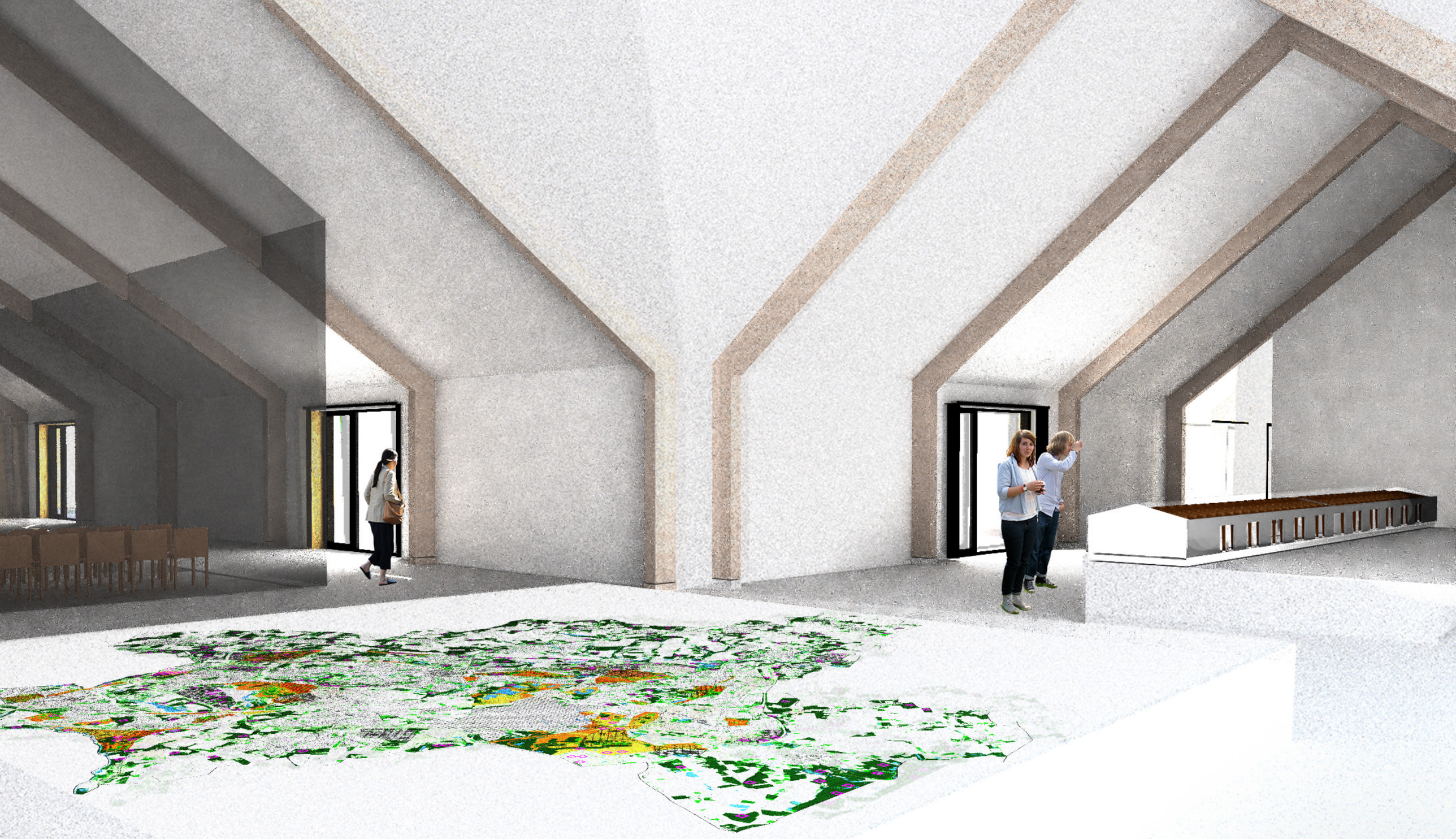
Construction
Kerto timber trusses

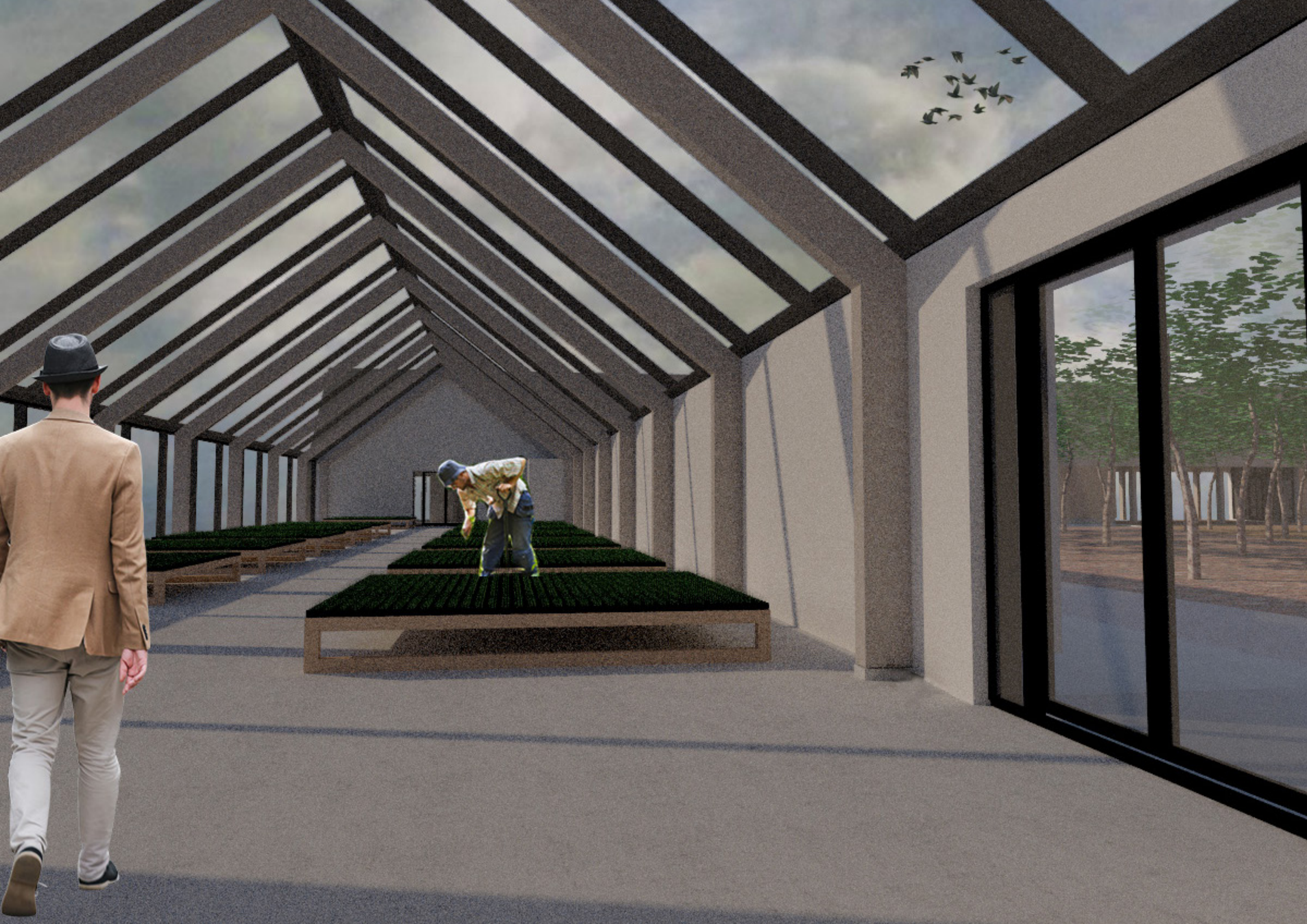
white wash











Thank you