COM\C

Shining New Light on Energy Efficiency
for Berlin's Sustainable Future

// | \\

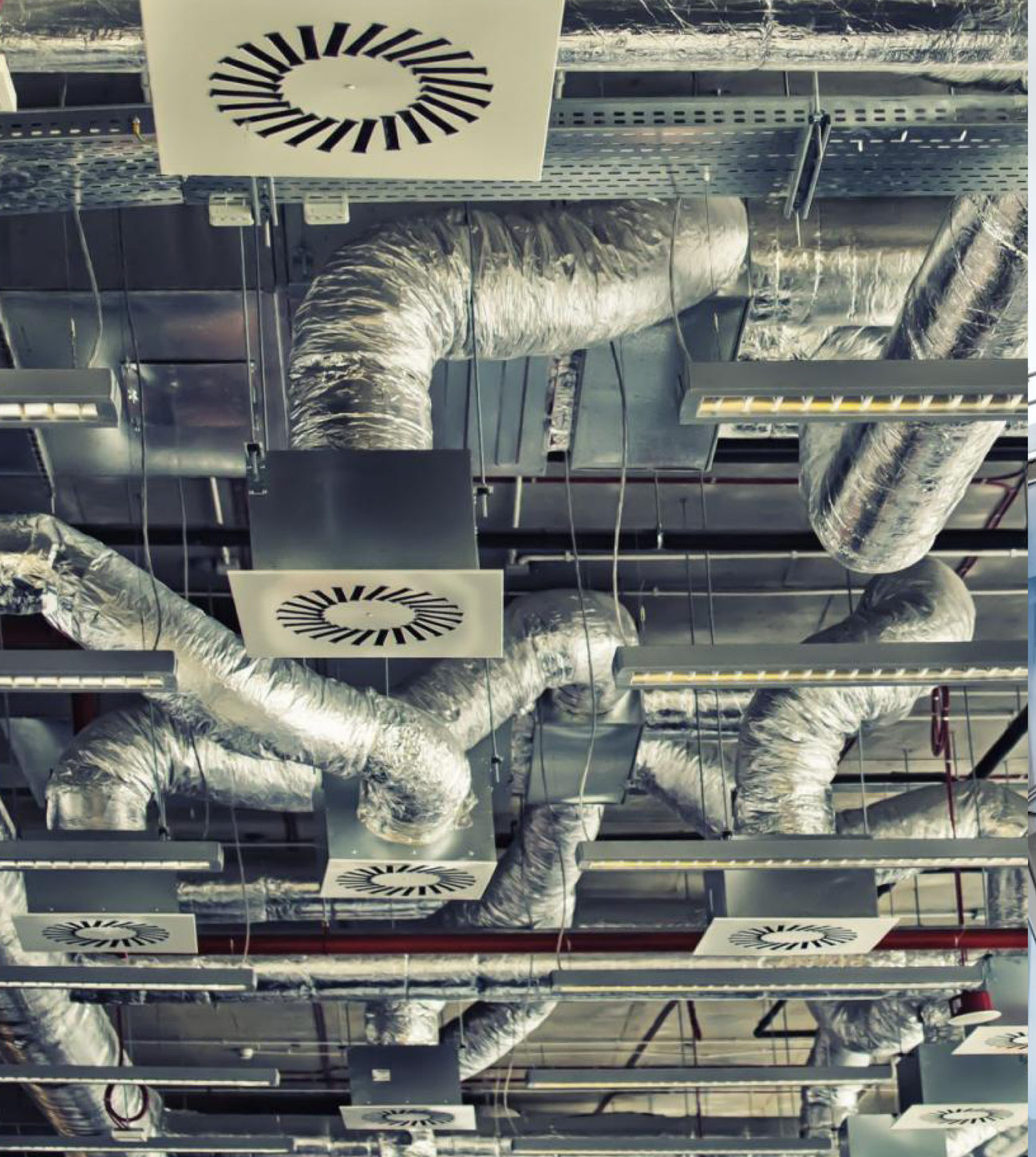
Architectural Engineering+ Graduation Studio
Mats Kolmas
4562135
23-06-2023



Komische Oper Theatre Extention


Skyscrapers





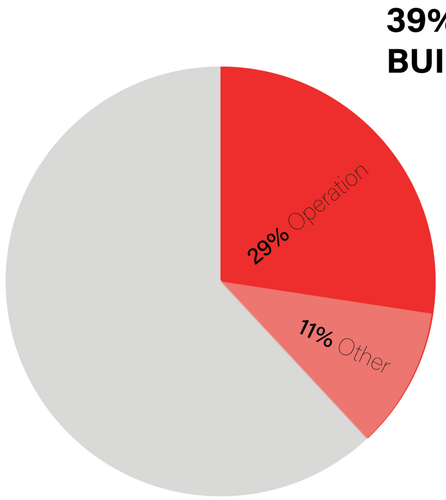


Mechanical Ventilation


Technology

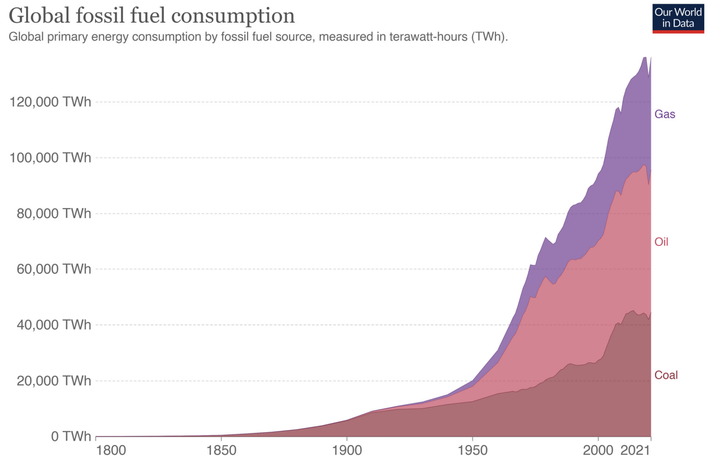
Global Energy Consumption

Built Environment



Global Fossil Fuel Consumption

All Industries



PROBLEM STATEMENT

Large Energy Consumption of the Built Environment

25 May 2021, 13:24 Charlotte Nijhuis

Many of Germany's public buildings not energy efficient – NGO report

#Efficiency

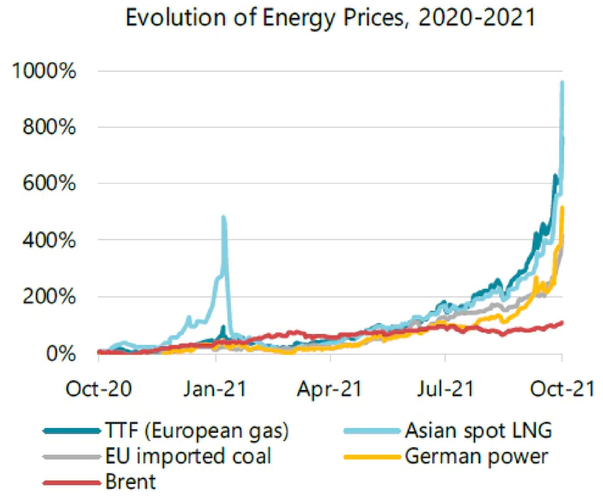
Germany to implement unprecedented measures to save energy

In autumn and winter, public buildings will not be heated more than 19 degrees Celsius, shops will turn off lights at night

Ayhan Simsek | 25.08.2022

Energy crisis: will the Germans sit in the theater without taking off their coats? | Culture and lifestyle in Germany and Europe | DW

Entertainment | August 22, 2022 | No Comments



ENERGY CRISIS 2021

Germany approves limits on heating public buildings to save energy

Measures will initially remain in place for six months as country aims to reduce its dependence on Russian gas



The Brandenburg Gate illuminated at night. Berlin has turned off the monument's lights. Photograph: Annegret Hilse/Reuters

Germany's government has approved a bylaw restricting the heating of public buildings and banning illuminated advertising hoardings, in an effort to save energy and tackle soaring energy costs.

27 Jul 2020, 13:11 Benjamin Wehrmann

Germany's energy-efficient renovation support programmes in high demand also amid pandemic

#Heating

Germany's €177bn climate budget to focus on renovations

By Nikolaus J. Kurmayer | EURACTIV 28 Jul. 2022

Saving energy has become a national challenge

A revival is noticeable throughout the country: many cultural institutions are already actively working on energy saving issues. If the small German city of Troisdorf has only just thought about this issue, the Prussian Cultural Heritage Foundation (Stiftung Preußischer Kulturbesitz) is already developing an action plan within the framework of the Taskforce strategic group created to solve energy saving problems.



POSTCARD BERLIN

Cultural centra



SUSTAINABLE BERLIN

Ambitious sustainable vision and goals

€

177.5 BILLION

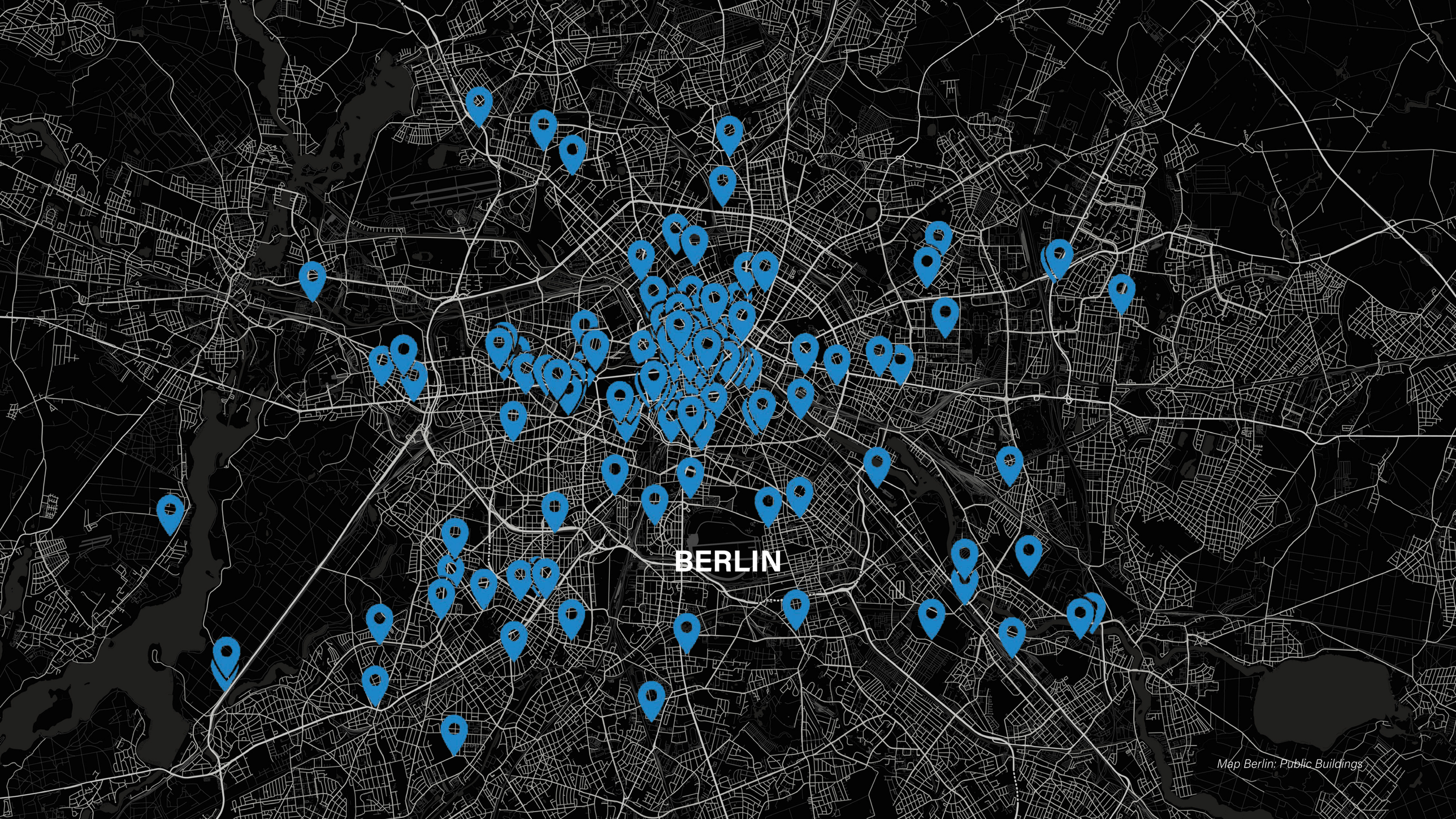
FEDERAL BUDGET RESERVED FOR CLIMATE ACTION FOR BUILDINGS

FINANCIAL SUBSIDIZING

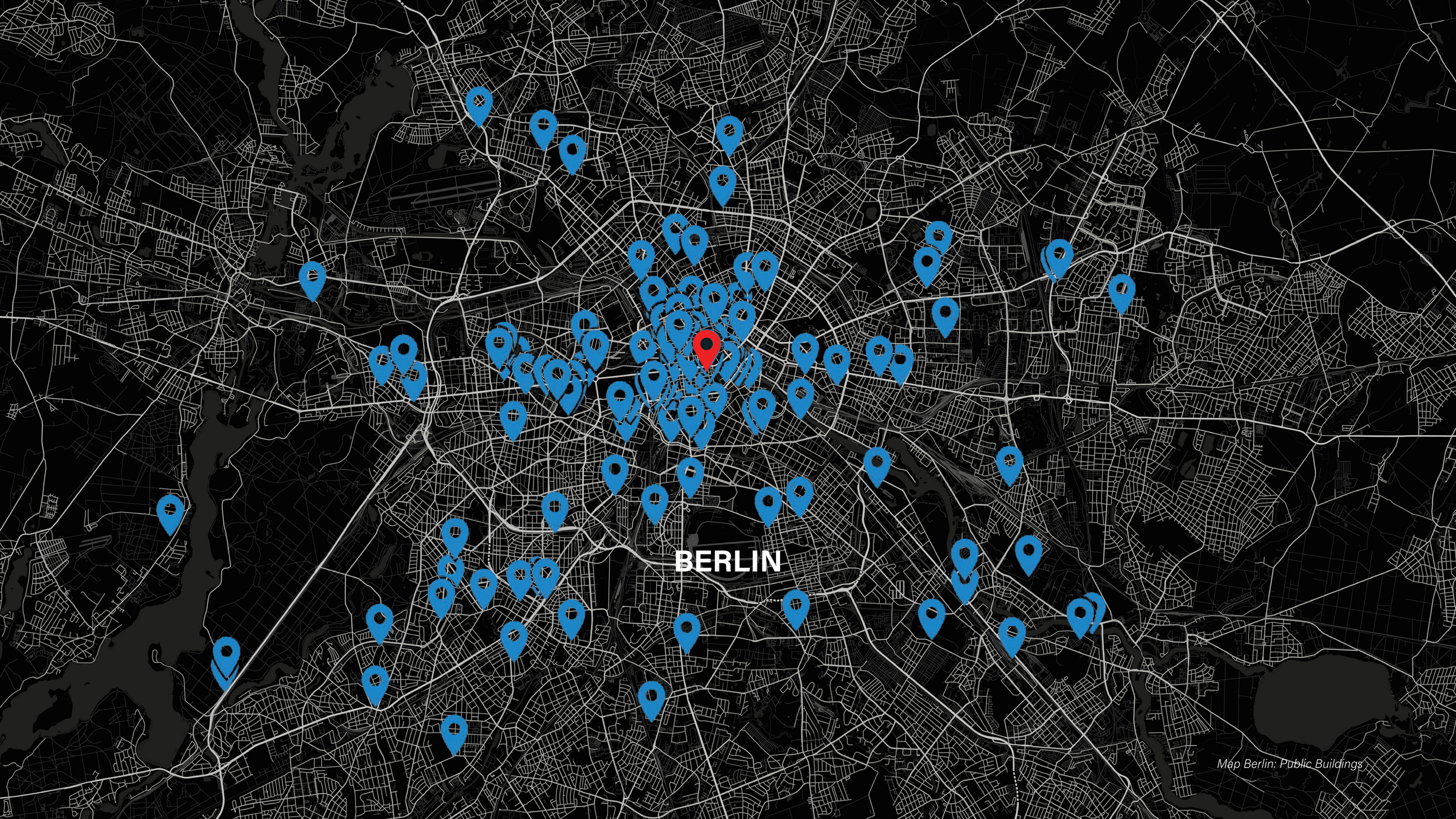
To support sustainable goals

Sustainable development means using **vision, imagination and creativity to shape the future**, and having the **courage to try new things** and **explore unfamiliar avenues**. It is about **how we would like to live in the future**, and how we respond to issues of the globalised world in both economy and in society.

– **Germany's Sustainable Development Strategy**:
The Federal Government



Map Berlin: Public Buildings



Map Berlin: Public Buildings



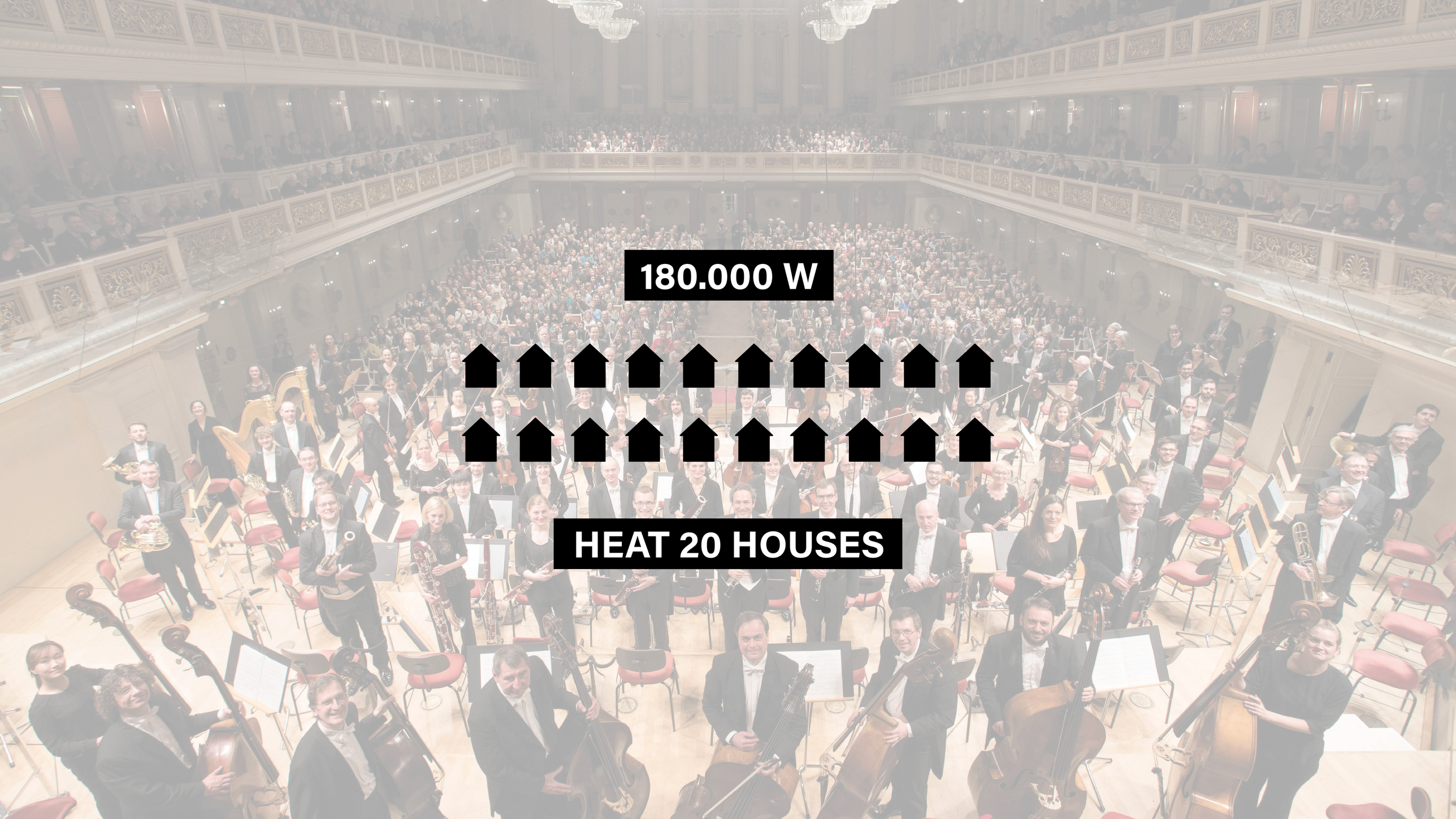
Konzerthaus, Berlin

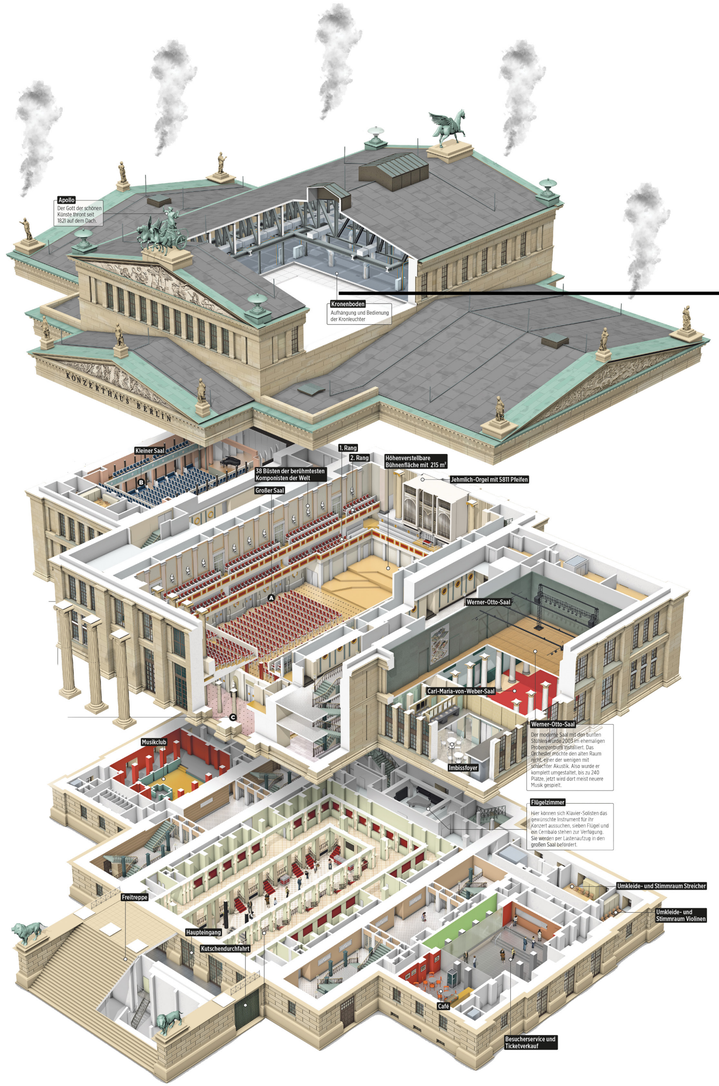


Main Concert Hall, Konzerthaus



Main Concert Hall, Konzerthaus


180.000 W
HEAT 20 HOUSES

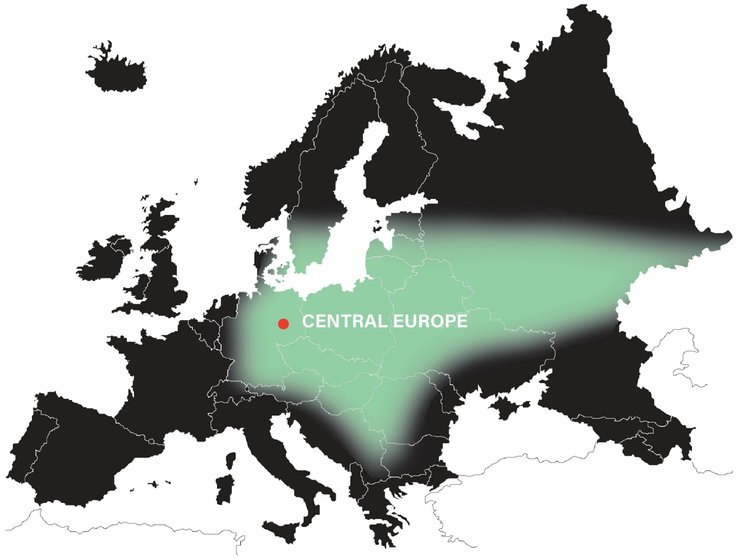


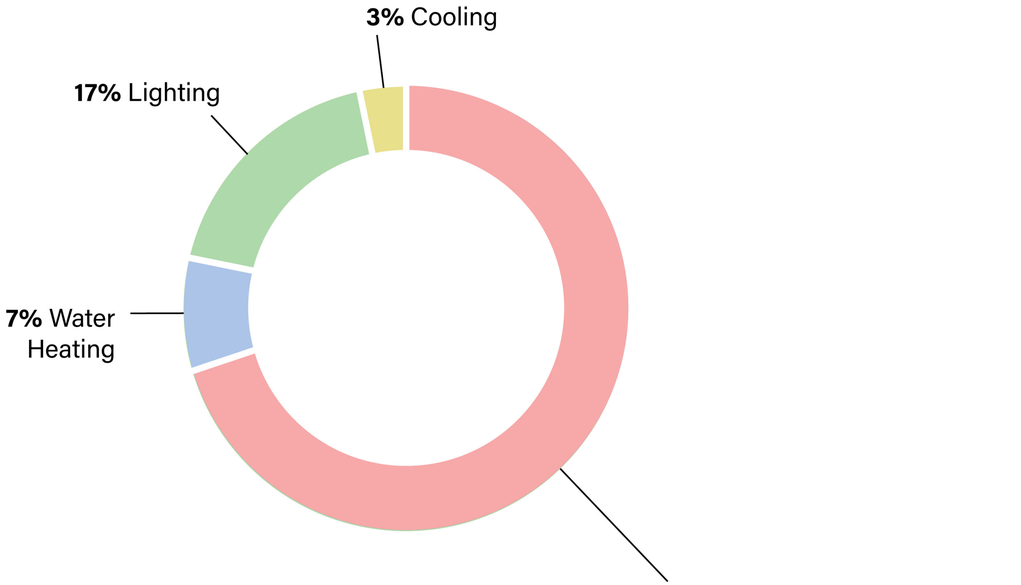






Mechanical Ventilation, Konzerthaus
Oct 2022

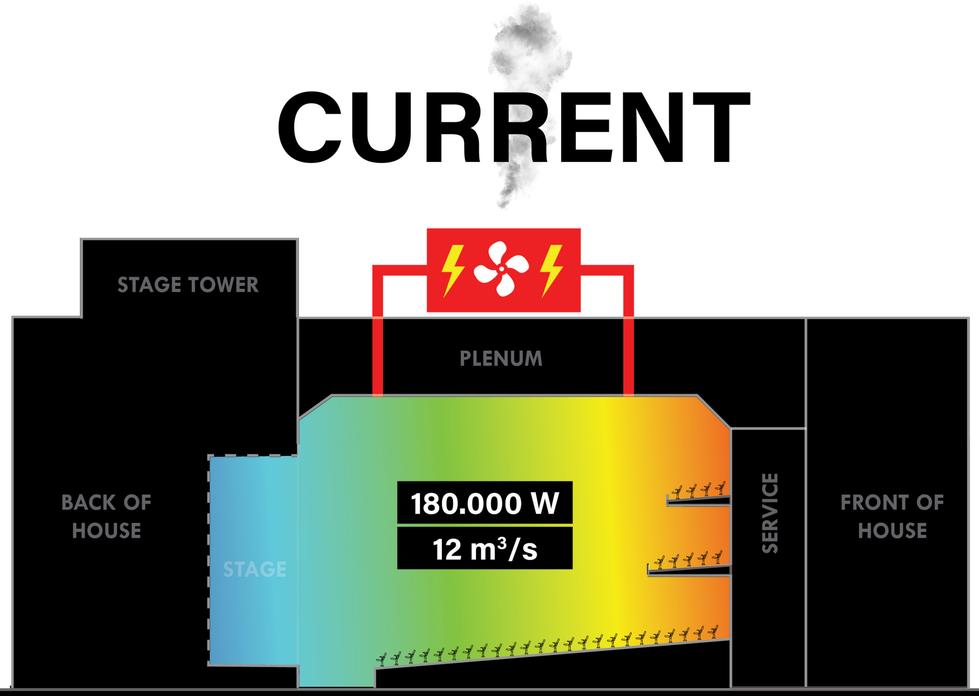




ENERGY CONSUMPTION NON RESIDENTIAL BUILDINGS

Predominant Heating Requirement

CURRENT

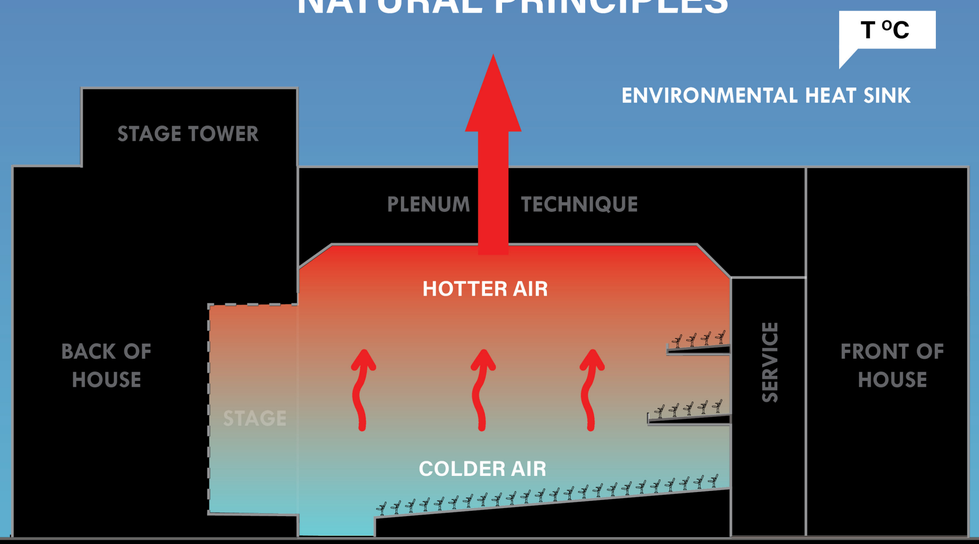


MECHANICAL VENTILATION

Autumn	Winter	Spring	Summer
12,0	2,4	12,5	21,9

RESEARCHED

NATURAL PRINCIPLES



A METHOD TO ALLOW FOR:

NATURAL VENTILATION BY BUOYANCY

Naturally Ventilated Theatre

An approach to naturally ventilate a theatre in Central European Climate using the stack- and solar chimney effect

Research Book

P2

Architectural Engineering Graduation Studio
Mats Kolmas
4562135

CONSIDERATIONS

PART 1: RETRIEVING INCOMING AIR

2 RETRIEVING AIR FROM OUTSIDE
3 CARDINAL INTAKE
4 AIR TEMPERATURE
5 PATH THROUGH BUILDING
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9 REGULATE AIRFLOWS

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11 VENTILATION BY BUOYANCY
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14 UPPER SIDE OF THE PLENUM

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16 AMOUNT OF EXHAUST CHIMNEYS
17 LENGTH OF EXHAUST CHIMNEYS
18 MATERIAL EXHAUST CHIMNEYS
19 TEMPERATURE EXHAUST CHIMNEYS
20 SOUND
21 WIND AND RAIN

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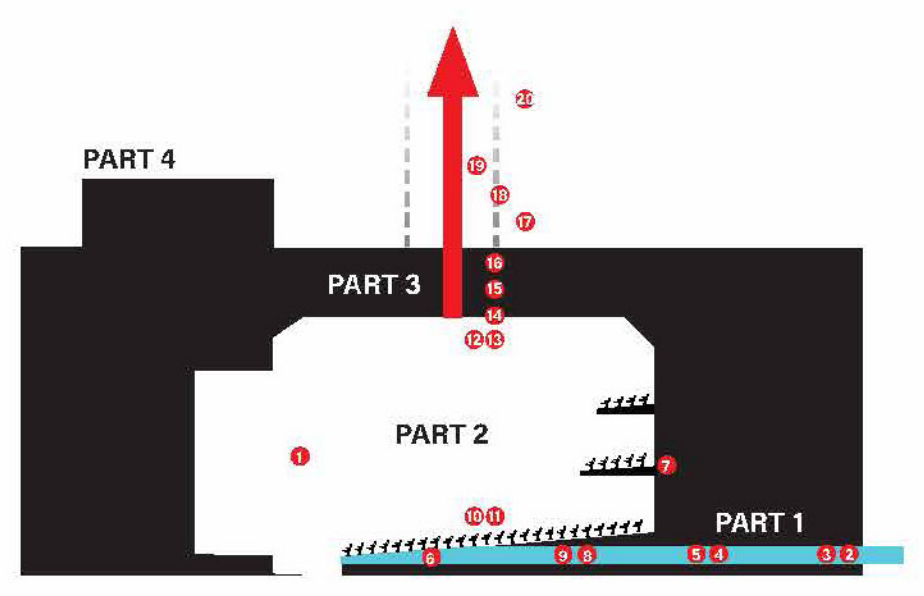
22 RE-USING THE HEAT
23 NIGHT TIME COOLING
24 THERMAL MASS



Monthly, Hourly Temperatures, Berlin, Germany

	January	February	March	April	May	June	July	August	Sept	October	Nov	Dec
1	1,5	-0,5	4,2	6,3	10,7	15,2	16,8	16,2	13,1	9,2	3,8	2,0
2	1,4	-0,6	4,0	5,9	10,3	14,7	16,3	15,8	12,7	8,9	3,7	1,9
3	1,4	-0,7	3,8	5,4	10,0	14,3	15,9	15,3	12,4	8,7	3,6	1,9
4	1,1	-1,0	3,7	5,0	9,8	13,7	15,5	15,0	12,2	8,5	3,5	2,1
5	1,2	-1,1	3,5	4,7	9,5	13,7	15,1	14,7	12,0	8,2	3,2	2,1
6	1,1	-1,1	3,3	4,7	10,3	14,4	15,4	14,6	12,1	7,9	3,1	2,1
7	1,1	-1,2	3,1	5,2	11,5	15,3	16,3	15,3	12,2	7,9	3,0	2,0
8	1,2	-1,2	3,3	6,6	12,8	16,3	17,2	16,4	13,1	8,2	2,9	2,1
9	1,3	-0,7	4,0	7,8	14,0	17,2	18,2	17,6	14,2	9,0	3,2	2,1
10	1,5	-0,2	4,9	8,9	15,1	18,1	19,5	18,7	15,2	10,0	3,7	2,2
11	2,0	0,6	5,8	9,8	16,1	19,1	20,4	19,8	16,1	10,7	4,5	2,4
12	2,6	1,2	6,9	10,4	16,7	19,8	20,9	20,4	17,1	11,6	5,4	2,8
13	2,9	1,7	7,4	11,0	17,2	20,6	21,8	21,2	17,9	12,4	6,1	3,2
14	3,1	2,0	7,7	11,6	17,7	21,1	22,3	21,7	18,5	12,9	6,4	3,3
15	3,1	2,1	8,0	11,6	17,7	21,2	22,9	22,1	18,6	13,0	6,4	3,4
16	2,9	2,1	8,1	11,7	18,0	21,2	23,0	22,1	18,4	13,0	6,1	3,3
17	2,7	1,7	7,8	11,6	18,0	20,9	22,8	22,0	18,0	12,4	5,7	3,0
18	2,4	1,2	7,3	11,1	17,2	20,2	22,4	21,8	17,2	11,6	5,3	2,8
19	2,2	1,0	6,5	10,2	16,6	19,5	21,6	21,0	16,4	11,2	4,9	2,6
20	1,9	0,8	6,1	9,3	15,4	18,7	20,6	20,0	15,6	10,8	4,7	2,4
21	1,8	0,5	5,6	8,7	14,1	17,5	19,4	19,0	15,0	10,3	4,5	2,3
22	1,6	0,3	5,5	7,9	13,4	17,0	18,7	18,2	14,3	9,9	4,3	2,3
23	1,5	0,1	4,9	7,3	12,4	16,4	17,9	17,5	13,7	9,7	4,2	2,2
24	1,4	-0,1	4,6	6,8	11,9	15,7	17,4	17,0	13,3	9,4	3,9	2,1

	Autumn	Winter	Spring	Summer
17	12,0	2,4	12,5	21,9
18	11,4	2,1	11,9	21,4
19	10,8	1,9	11,1	20,7
20	10,4	1,7	10,3	19,8
21	9,9	1,6	9,5	18,6
22	9,5	1,4	8,9	18,0

Seasonal Temperatures, Berlin, Germany

→

	Summer	Winter	Inbetween
17	21,9	2,4	12,2
18	21,4	2,1	11,6
19	20,7	1,9	11,0
20	19,8	1,7	10,3
21	18,6	1,6	9,7
22	18,0	1,4	9,2

Seasonal Temperatures, Berlin, Germany

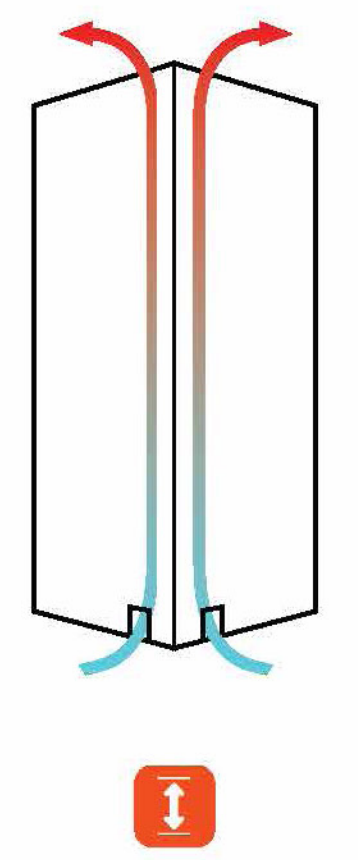
SEASONAL DIFFERENCES

SUMMER 18 - 22 °C — PRECOOL

WINTER 1,4 - 2,4 °C — PREHEAT

INBETWEEN 9,2 - 12,2 °C — MINIMAL ADJUSTMENTS

4 **AIR TEMPERATURE**



STACK EFFECT

The rising of hot air through a building, creating a natural loop, inhaling colder air through the bottom.

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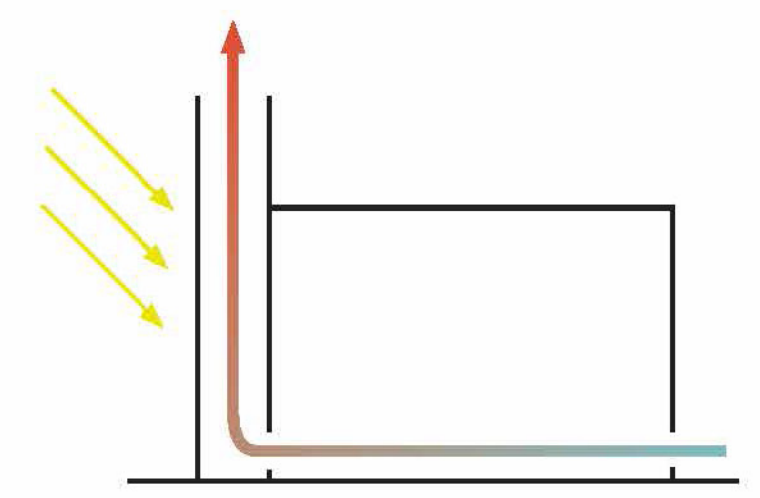


SOLAR CHIMNEY

Air gets heated by solar rays heating up the air inside a chimney, creating natural movement of air.

HEAT DISSIPATION

HEAT DISSIPATION AT GIVEN VENTILATION RATE

12 m³/s (MIN. VENTILATION) ↔ **200.000 W** (BODY HEAT + LIGHT)

$$\Delta W = \rho c_{air} Q.f\Delta T\ [W]$$

dW = warmteafvoer door ventilatie in W
dcair = specifieke warmte lucht = 1200 J/m3K
Q = ventilatiehoeveelheid in m3/s
dT = gemiddelde temperatuurverschil tussen binnen en buiten
f = factor voor verschil tussen gemiddelde temperatuurverschil en Tuit-Tin

f = Tuit-Tin / delta T = (Tuit-Tbuiten) / (Tgem-Tbuiten)

1200 | 12 m/s | 1,9 / 20,1 / 11,3 | 1,5

	Summer	Winter	Inbetween
17	21,9	2,4	12,2
18	21,4	2,1	11,6
19	20,7	1,9	11,0
20	19,8	1,7	10,3
21	18,6	1,6	9,7
22	18,0	1,4	9,2
average (°C)	20,1	1,9	10,7
inside (19-25 °C)	22	22	22
difference (°C)	1,9	20,1	11,3

HEAT DISSIPATION PER SEASON

SUMMER 18 - 22 °C — 41 kW — Note: Need extra fan assistance to dissipate heat

WINTER 1,4 - 2,4 °C — 435 kW ✓

INBETWEEN 9,2 - 12,2 °C — 244 kW ✓

10 **HEAT DISSIPATION PER SEASON**

TEMPERATURE RISE IN CHIMNEY

$$\Delta T = \frac{0{,}0279 \cdot \Delta W^{\frac{2}{3}}}{h^{\frac{1}{3}} \cdot f^{\frac{2}{3}} . A_e^{\frac{2}{3}}} = 0{,}0279\left(\frac{\Delta W^2}{h \cdot f^2 A_e^{\,2}}\right)^{\frac{1}{3}}$$

dT = temperatuurverschil tussen binnen en buiten
dW = warmteafvoer door ventilatie
h = hoogteverschil tussen toevoeropening en afvoeropeningen in m
Ae = equivalente ventilatieopening in m2
f = Tuit-Tin / delta T = (Tuit-Tbuiten) / (Tgem-Tbuiten)

ΔW = Internal heat production (W) → **200.000 W**

\+

SOLAR HEAT

Solar heat gain (W) = $A_{exposed}$ (m²) * Solar radiation (W/m²)

\+

ADDITIONAL EXHAUSTS

W = Exhaust of the rest of the builidng

ΔW = Internal heat production (W)+ Solar heat gain (W) + Additional Exhaust (W)

SOLAR HEAT RADIATION

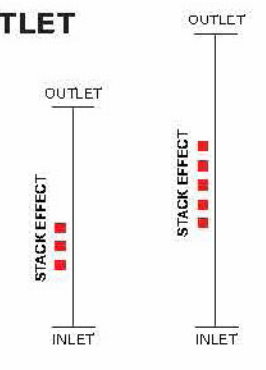
Month	1	2	3	4	5	6	7	8	9	10	11	12
Radiation	149	223	369	418	418	459	448	403	346	275	251	118

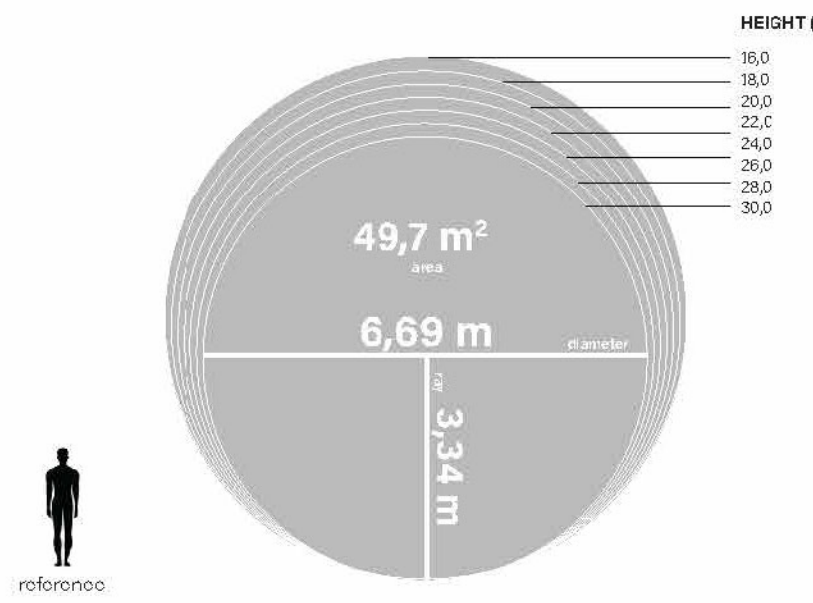
Average hourly monthly solar heat radiation (W/m²)

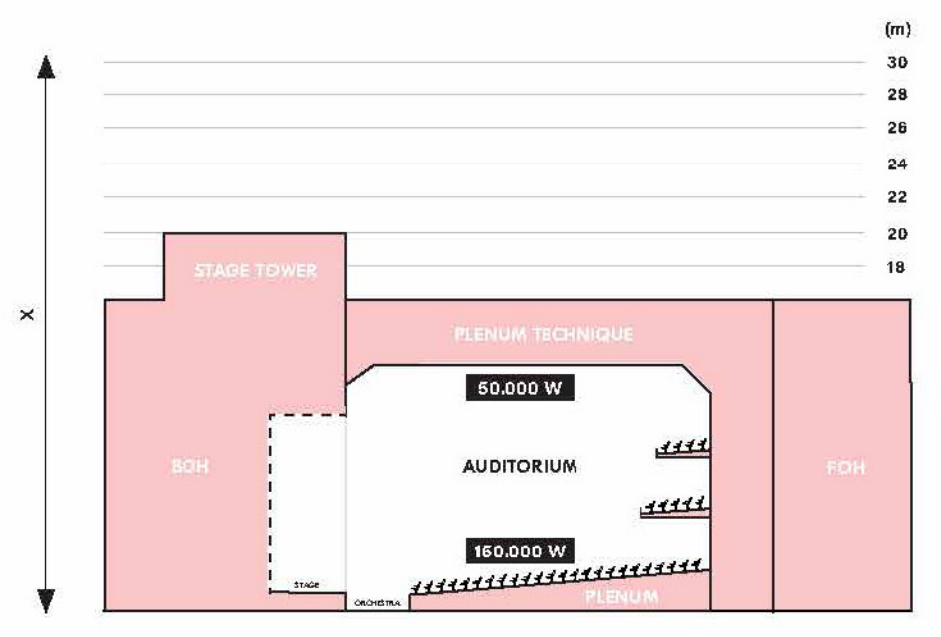
19 **TEMPERATURE OF EXHAUST CHIMNEYS**

VARYING HEIGTH BETWEEN IN- AND OUTLET

HEIGHT (m)	Ae (m²)	Ai (m²)	RAY	DIAMETER
16	48,1	68,0	3,91	7,83
18	45,4	64,2	3,80	7,60
20	43,0	60,9	3,70	7,40
22	41,0	58,0	3,61	7,23
24	39,3	55,6	3,54	7,07
26	37,7	53,4	3,47	6,93
28	36,4	51,4	3,40	6,80
30	35,1	49,7	3,34	6,69



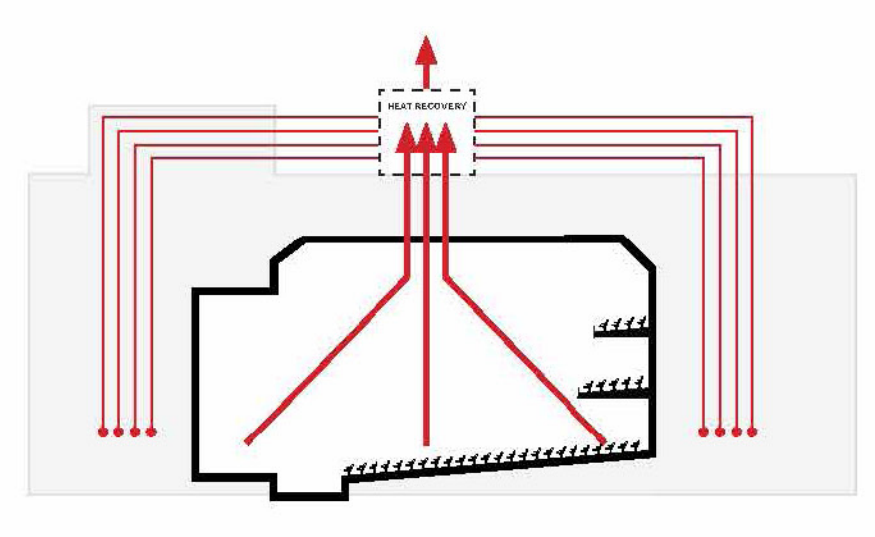




HEIGHT ABOVE THEATRE

Stack effect heights

8 **SIZE OF THE AIRINLET**



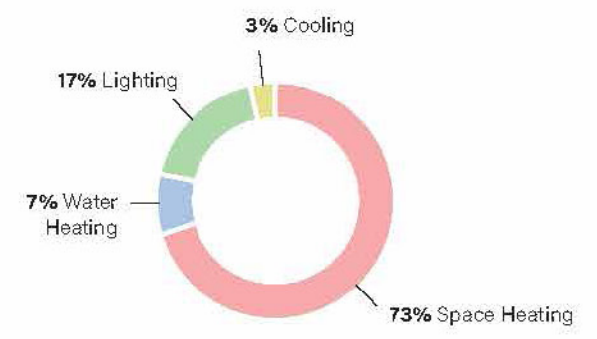
HEAT RECOVERY

As all the heat naturally centralizes in one or multiple locations, these spaces offer good space for heat recovery of the heated air. This can be used to heat other parts of the building.



CENTRAL EUROPEAN REGION

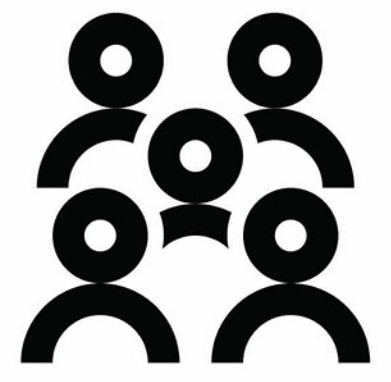
Location of Berlin



AVERAGE ENERGY CONSUMPTION

Non-residential

22 **RE-USING THE HEAT**



FULL OCCUPANCY

200.000 W

NATURAL VENTILATION DUE TO HEAT

TEMPERATUURVERSCHIL DOOR HITTE PRODUCTIE

$$\Delta T = \frac{0{,}0279 \cdot \Delta W^{\frac{2}{3}}}{h^{\frac{1}{3}} \cdot f^{\frac{2}{3}} . A_e^{\frac{2}{3}}} = 0{,}0279\left(\frac{\Delta W^2}{h \cdot f^2 A_e^{\,2}}\right)^{\frac{1}{3}}$$

dT = temperatuurverschil tussen binnen en buiten
dW = warmteafvoer door ventilatie
h = hoogteverschil tussen toevoeropening en afvoeropeningen in m
Ae = equivalente ventilatieopening in m2
f = Tuit-Tin / delta T = (Tuit-Tbuiten) / (Tgem-Tbuiten)

200.000 W | 24 m | 29,5 m² | 1,5

ΔT = 2,65 °C

BIJKOMENDE VENTILATIEVOUD

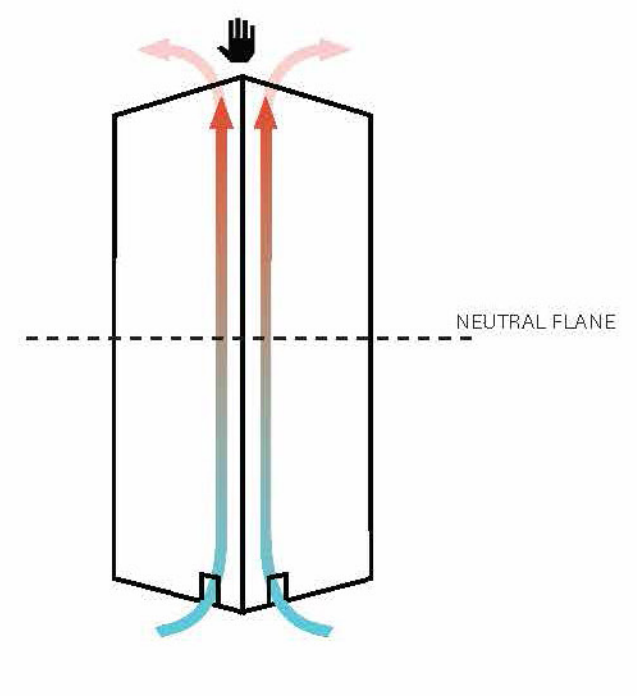
$$Q = C_D \times A_e \sqrt{2gh \times \Delta T / T_a}\ [m^3/s]$$

Q = ventilatiehoeveelheid in m3/s
Cd = weerstandcoefficient, tussen 1 en 0,7
hg = zwaartekrachtconstrante = 9,8 m/s2
h = hoogteverschil tussen toevoeropening en afvoeropeningen in m
dT = gemiddelde temperatuurverschil tussen binnen en buiten
Ta = buitentemperatuur in K (circa 300 K)
Ae = equivalente ventilatieopening in m²

0,85 | 9,8 m/s² | 24 m | 3 °C | 296 K | 29,5 m²

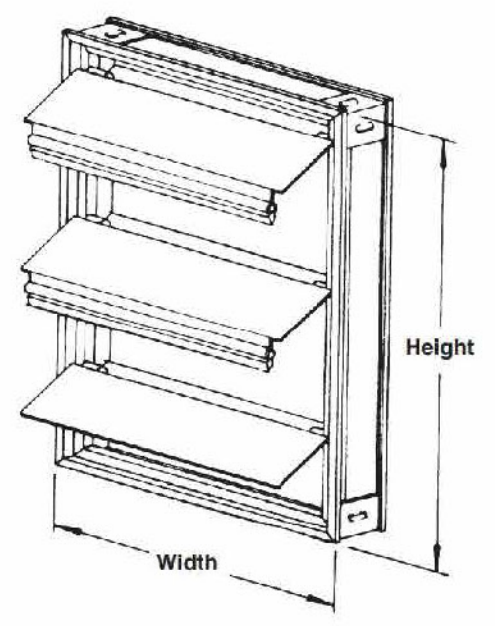
Q= **51,42 m³/s** > **12 m³/s** ✓

11 **VENTILATION BY BUOYANCY**



STACK EFFECT

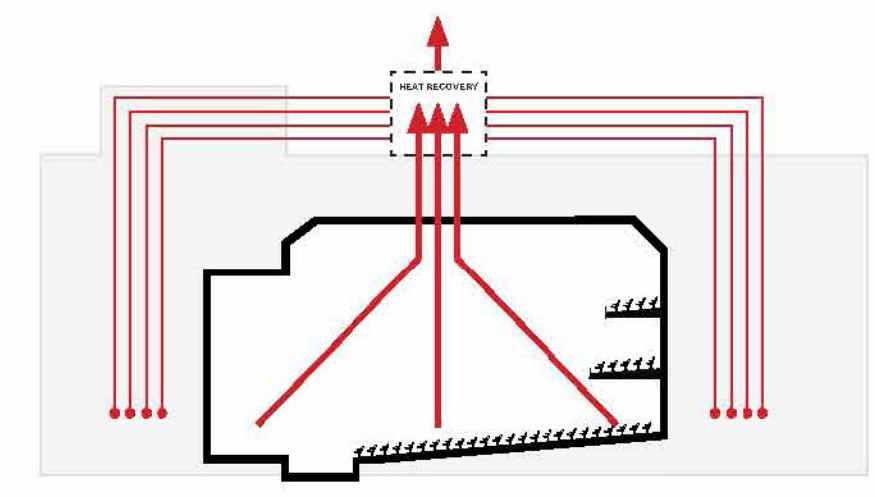
Most important to stop the air from flowing out, if you want to stop the stack effect. If the air cannot flow out, new air cannot enter



ACTUATOR CONTROLLED DAMPERS

Installed into shafts or doorways may dampers play a role in the stopping of air. These can be controlled by sensors or the building manager.

9 **REGULATE AIRFLOWS**



HEAT RECOVERY

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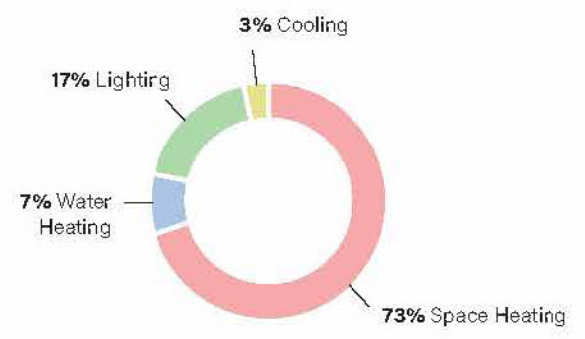
CENTRAL EUROPEAN REGION

Location of Berlin



AVERAGE ENERGY CONSUMPTION

Non-residentia

22 **RE-USING THE HEAT**

LENGTH OF UNDERGROUND DUCTS

$$l = \frac{(T_{out} - T_{in})\left(\frac{1}{\alpha_i} + \frac{d}{\lambda}\right) v\, r \rho c_l}{2(T_{ground} - T_{in})}$$

l = length of the necessary ducts (m)
T_{out} = temperature of the outgoing air (°C)
T_{in} = temperature of the ingoing air (°C)
α_i = the heat transfer coefficient between the surface of the duct and the air
c/λ = thermal conductivity (m²/K/W)
T_{ground} = temperature of the ground (°C)
ρc_lair = specific heat air = 1200 J/m3K
v = velocity (m/s)
r = radius (m)

20 °C | 24 °C | 10 m²K/W | 0,02 m²K/W | 14 °C | 1200 J/m³K | 1 m/s | 3,91 m

T_{in} **24 °C** → T_{out} **20 °C**

l = **72 meter**

COOLING CAPACITY

$$Q = mCp\Delta T$$

Q = cooling capacity (W)
Cp = specific heat air = 1200 J/m³K
m = mass flow of air (m³/s)
dT = temperature difference

1200 J/m³K | 12 m³/s | 4 °C

Q = 57,6 kW

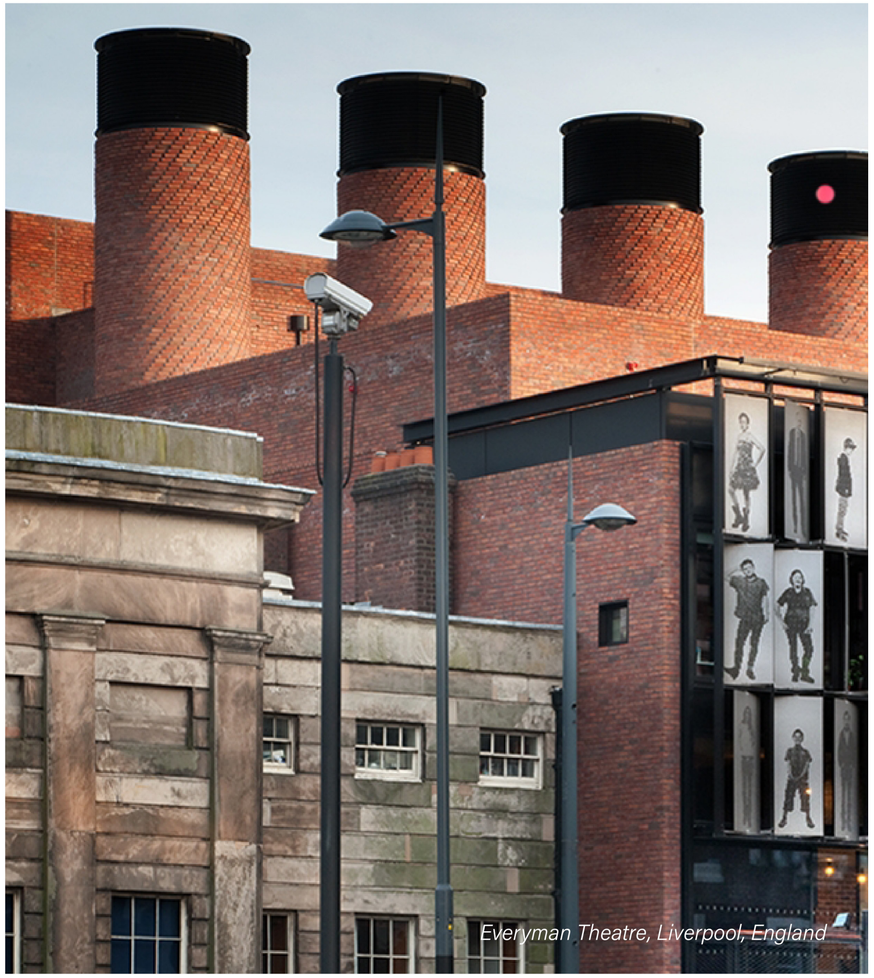
Substract

HEAT PRODUCTION **200.000 W**

COOLING CAPACITY **57.600 W** −

COOLING LOAD

5 **PATH THROUGH BUILDING**



Everyman Theatre, Liverpool, England

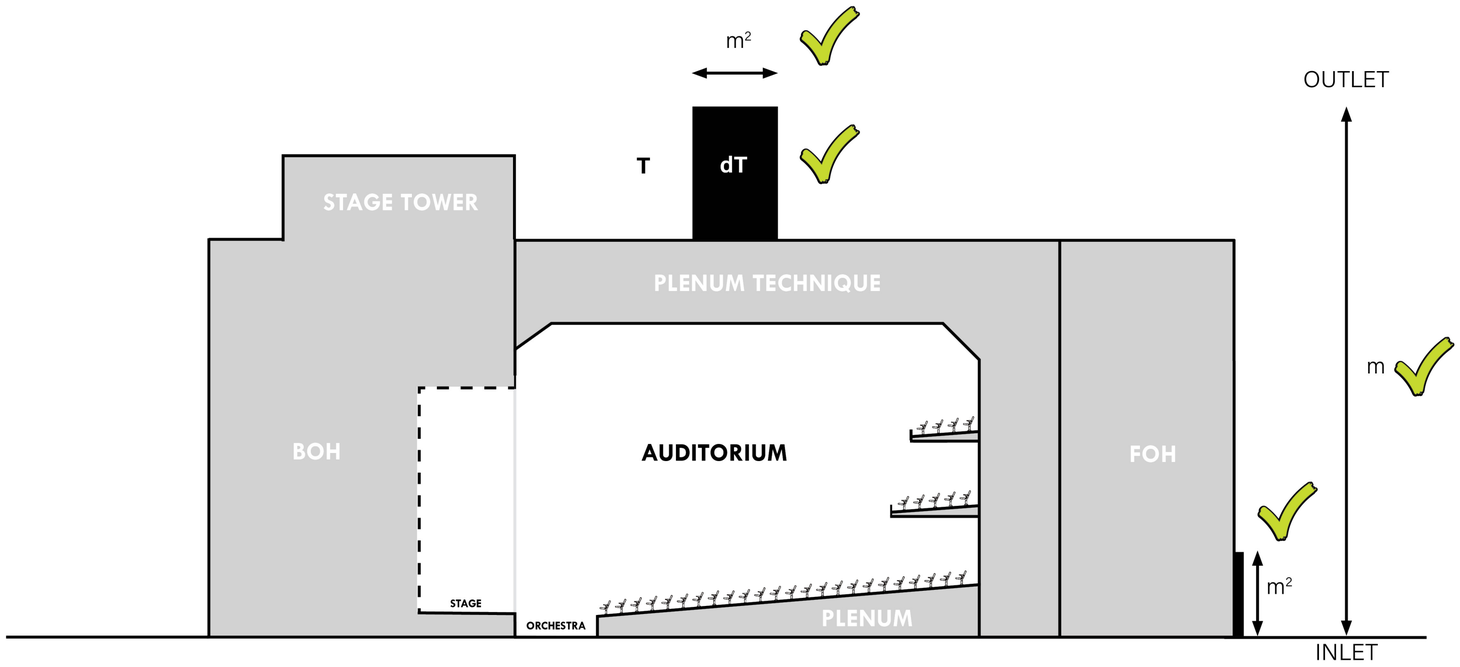


The Contact Theatre, Manchester, England

REFERENCES

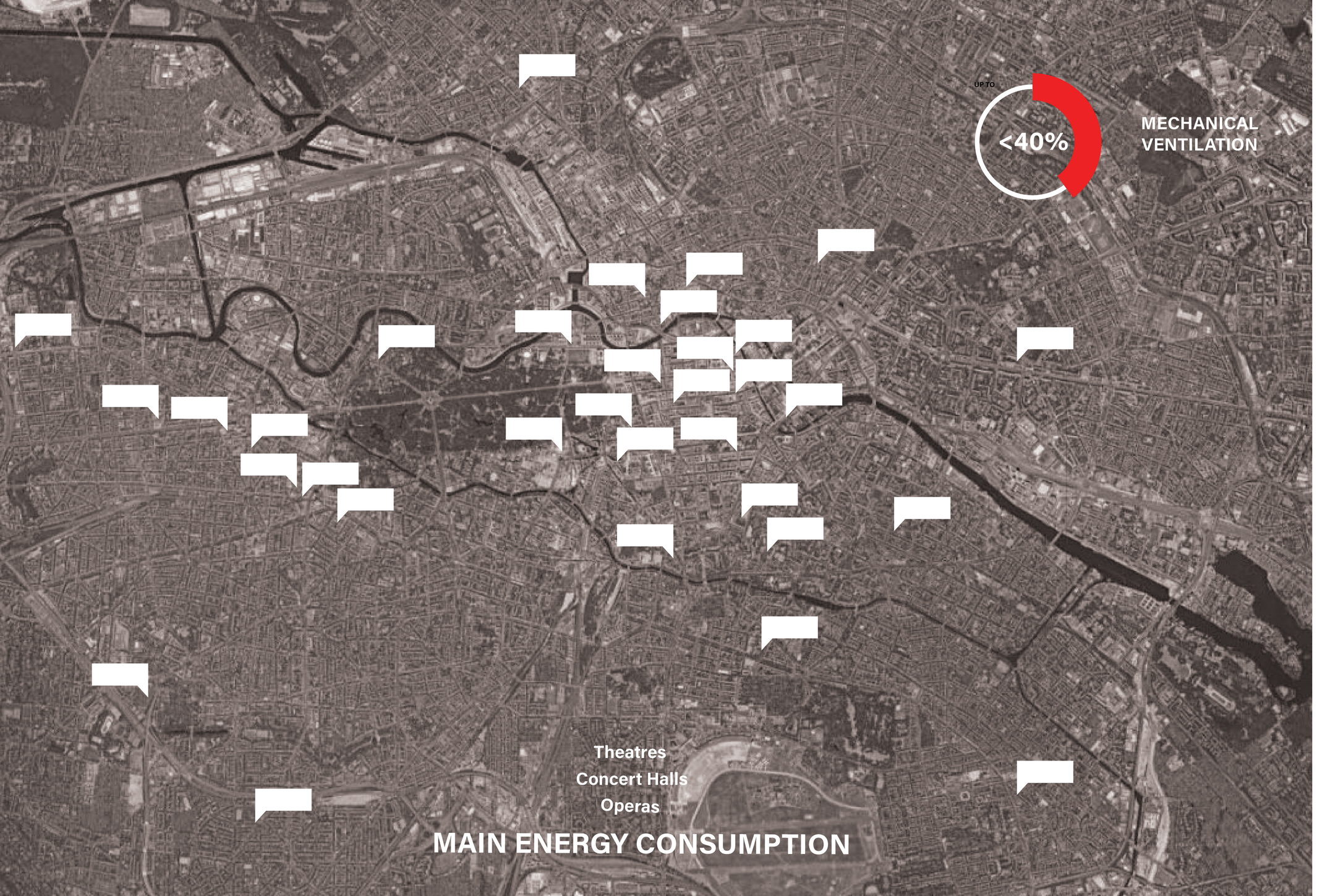
Chimneys, Theatres in England

IMPORTANT PARAMETERS

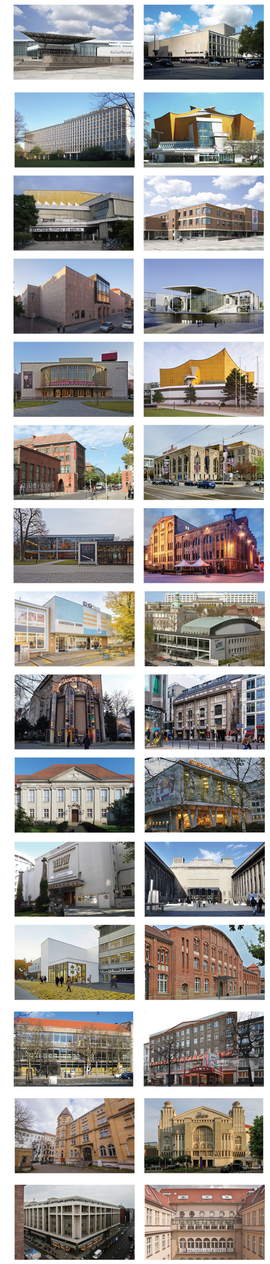


THEORETICAL FRAMEWORK

For the stimulance of Natural Ventilation of Complex Spaces



RESEARCHED BUILDINGS



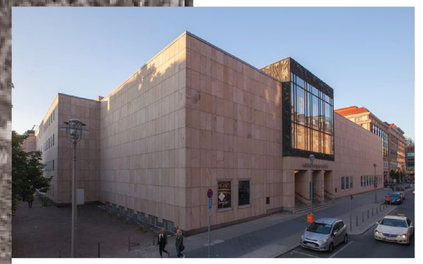
NO MECHANICAL VENTILATION

PLANNED RENOVATION

Theatres
Concert Halls
Operas

MAIN ENERGY CONSUMPTION

RESEARCHED BUILDINGS



KOMISCHE OPER BERLIN


KOMISCHE OPER



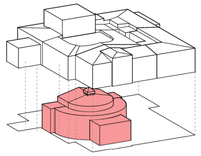
KOMISCHE OPER

Exterior



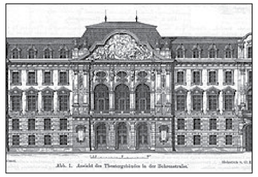
KOMISCHE OPER

Interior



OPENED

The Neo-Baroc Style Theatre opened its doors to the public



1892

REMAINS

The remains of the theatre were reconstructed into and operational theatre



1950

REBUILT

A simplistic monolite block was added around the theatre for more functions



1966

1945



BOMBED

The buildings was bombed at the end of the World War II and only the Core Remained Standing

1987



LAST RENOVATION

Last structural renovation including insulation and technique.

+

PLANNED RENOVATION AND EXTENSION

To prepare the institution for a prominent player in the future of performance



2023

FUTURE THEATRE

Opening the world of theatre to the public

?

Future

timeline

EXTENTION

Repetition Spaces **1750 m²**

Public Cafe **500 m²**

Public Foyer **500 m²**

Meeting Spaces **1100 m²**

Orchestra Music Spaces **1500 m²**

Administration **1500 m²**

Casino **500 m²**

Other **1000 m²**

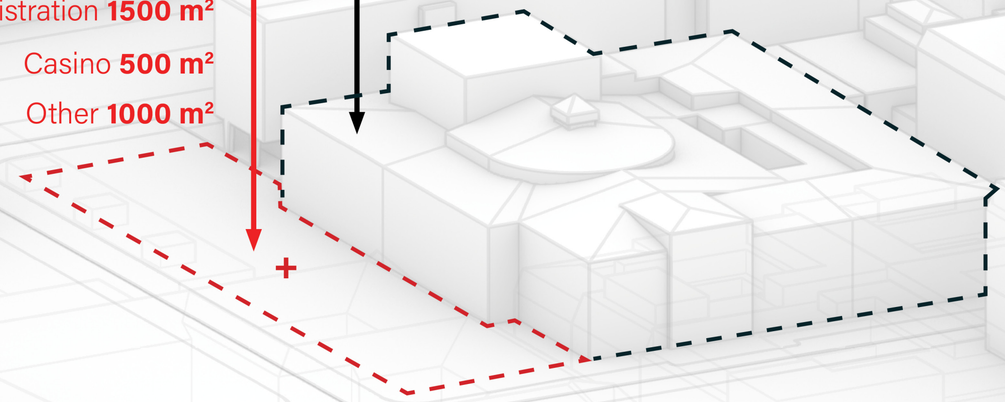
EXISTING

Auditorium **650 m²**

Foyer **950 m²**

Back of House **6000 m²**

Front of House **3000 m²**



Sustainable development means using **vision, imagination and creativity to shape the future**, and having the **courage to try new things** and **explore unfamiliar avenues**. It is about **how we would like to live in the future**, and how we respond to issues of the globalised world in both economy and in society.

Die Bundesregierung

CLIENT



+



INNOVATIVELY SUSTAINABLE

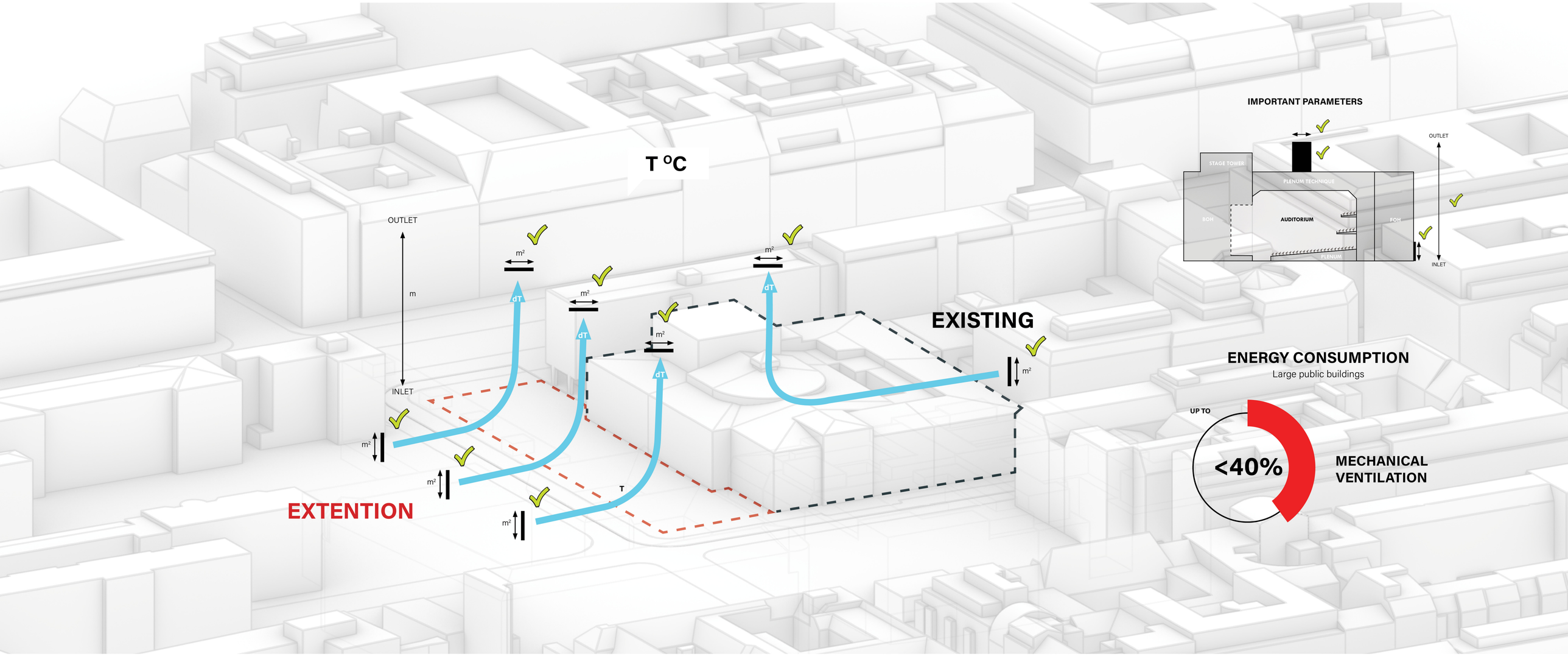
Development of new sustainable solutions for the built environment

REINTRODUCE THE THEATRE TO THE CITY

Open the world of theatre and opera to the city and beyond

KEY POINTS

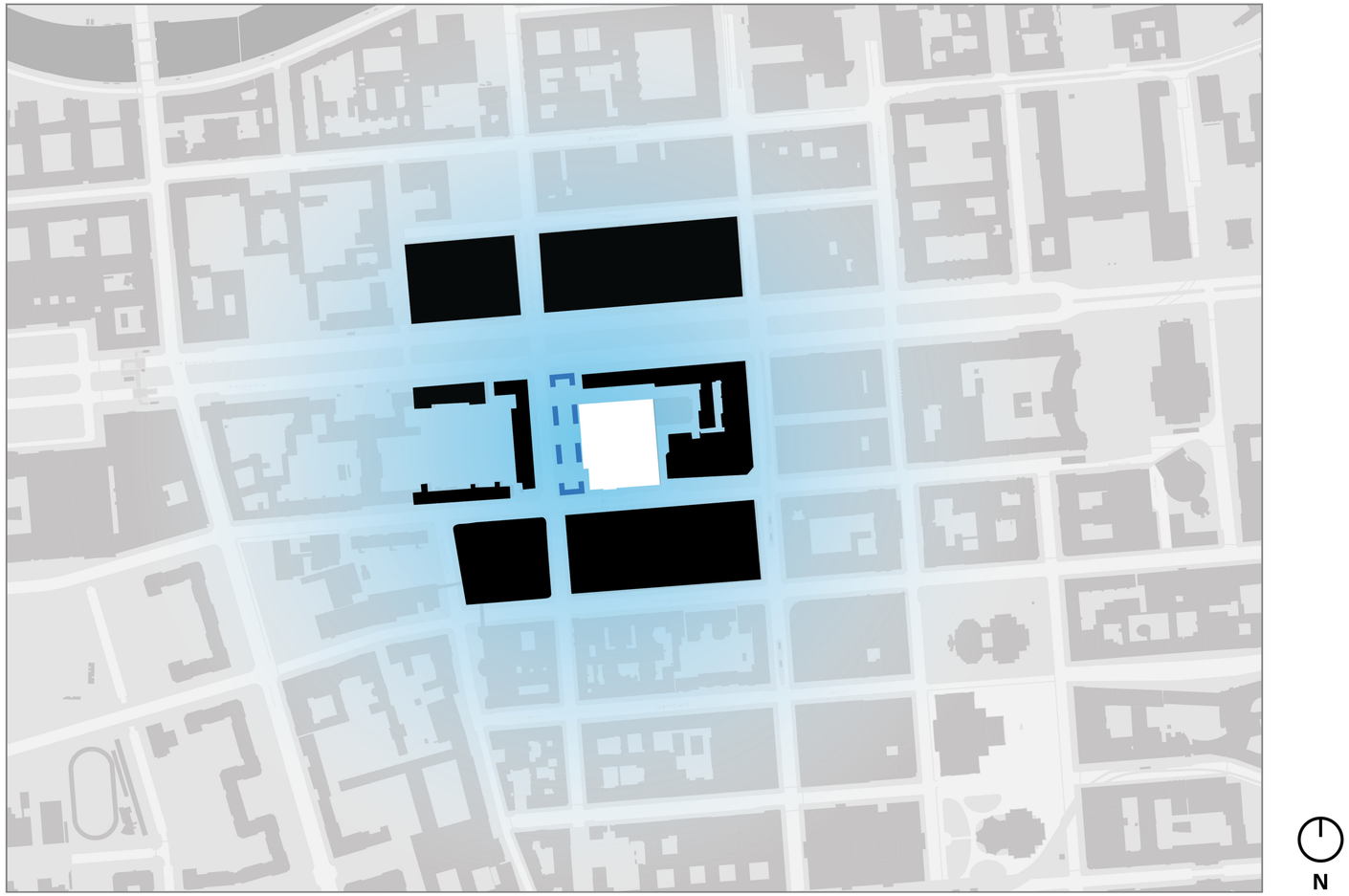
Komische Oper Berlin, Germany


T °C
OUTLET
m
INLET
m²
dT
T
EXTENTION
EXISTING
IMPORTANT PARAMETERS
STAGE TOWER
PLENUM TECHNIQUE
BOH
AUDITORIUM
FOH
PLENUM
OUTLET
INLET
ENERGY CONSUMPTION
Large public buildings
UP TO
<40%
MECHANICAL
VENTILATION



CONTEXT

Current situation of the Komische Oper Theatre



CONTEXT

Current situation of the Komische Oper Theatre



GREEN STRIP

One green axis throughout the neighborhood



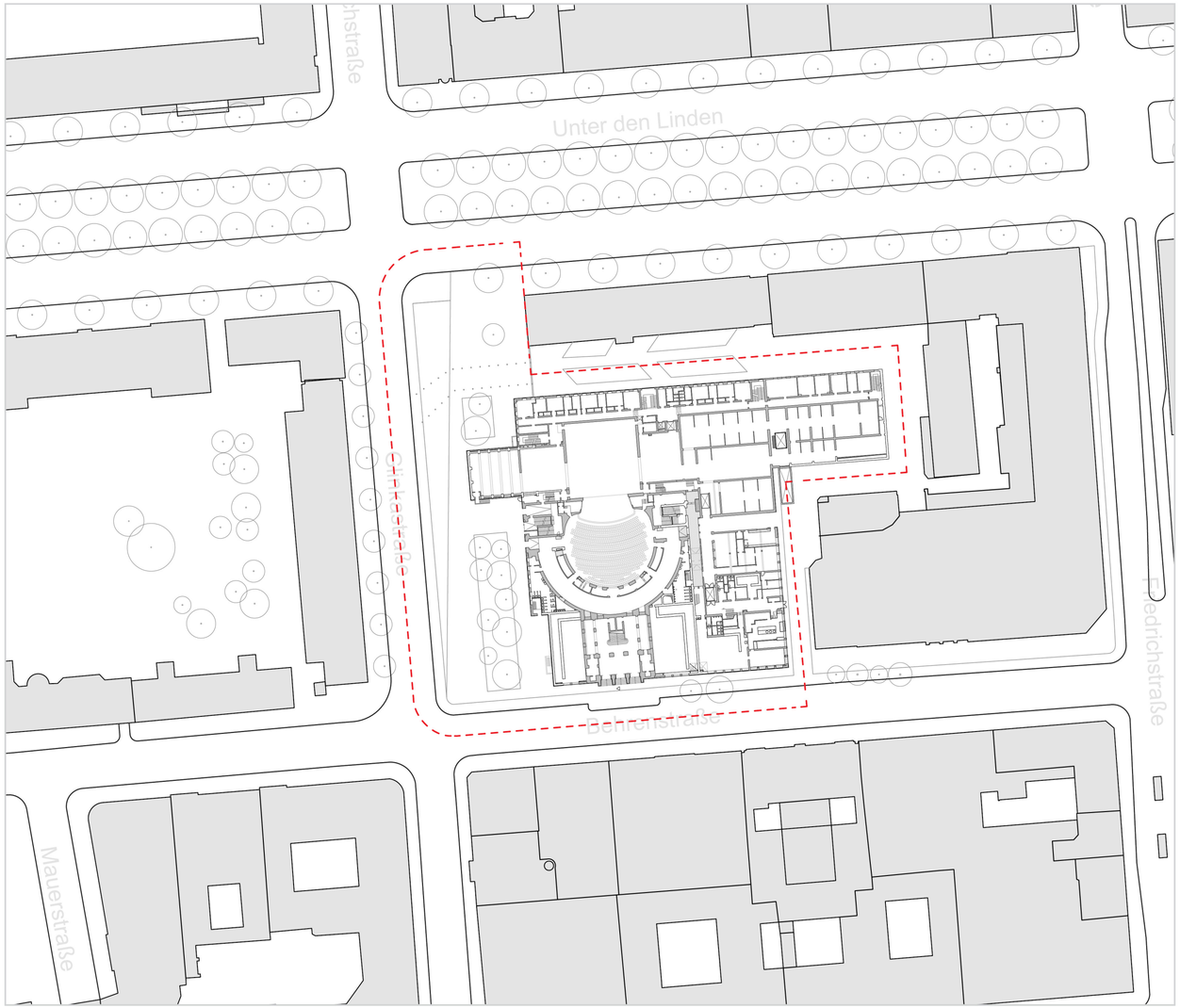
GREEN STRIP

Future of Mobility: Pedestrian Axis



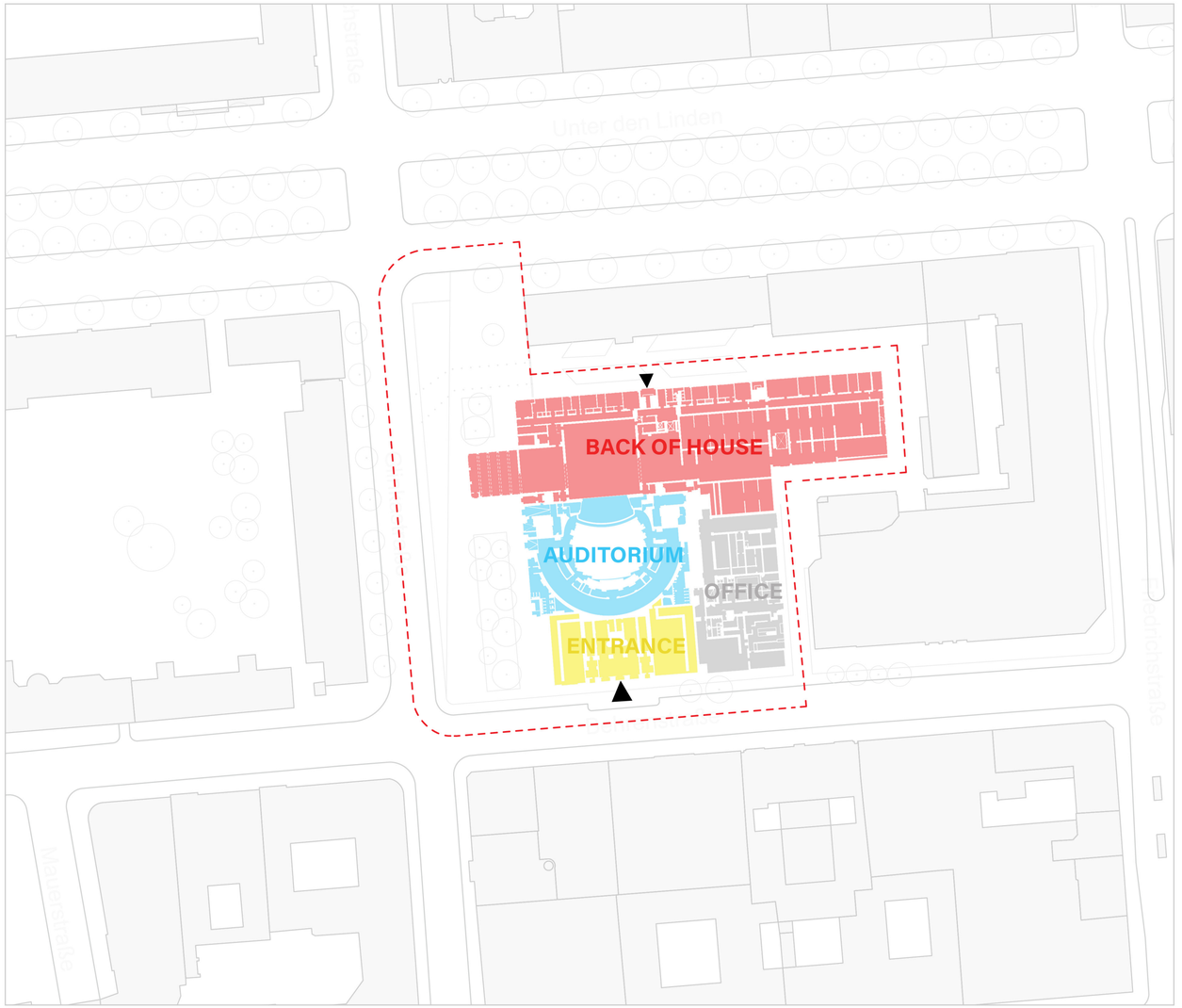
MAIN PEDESTRIAN STREETS

Future of Mobility: Pedestrian Axis



SITE PLAN

Current situation of the Komische Oper Theatre

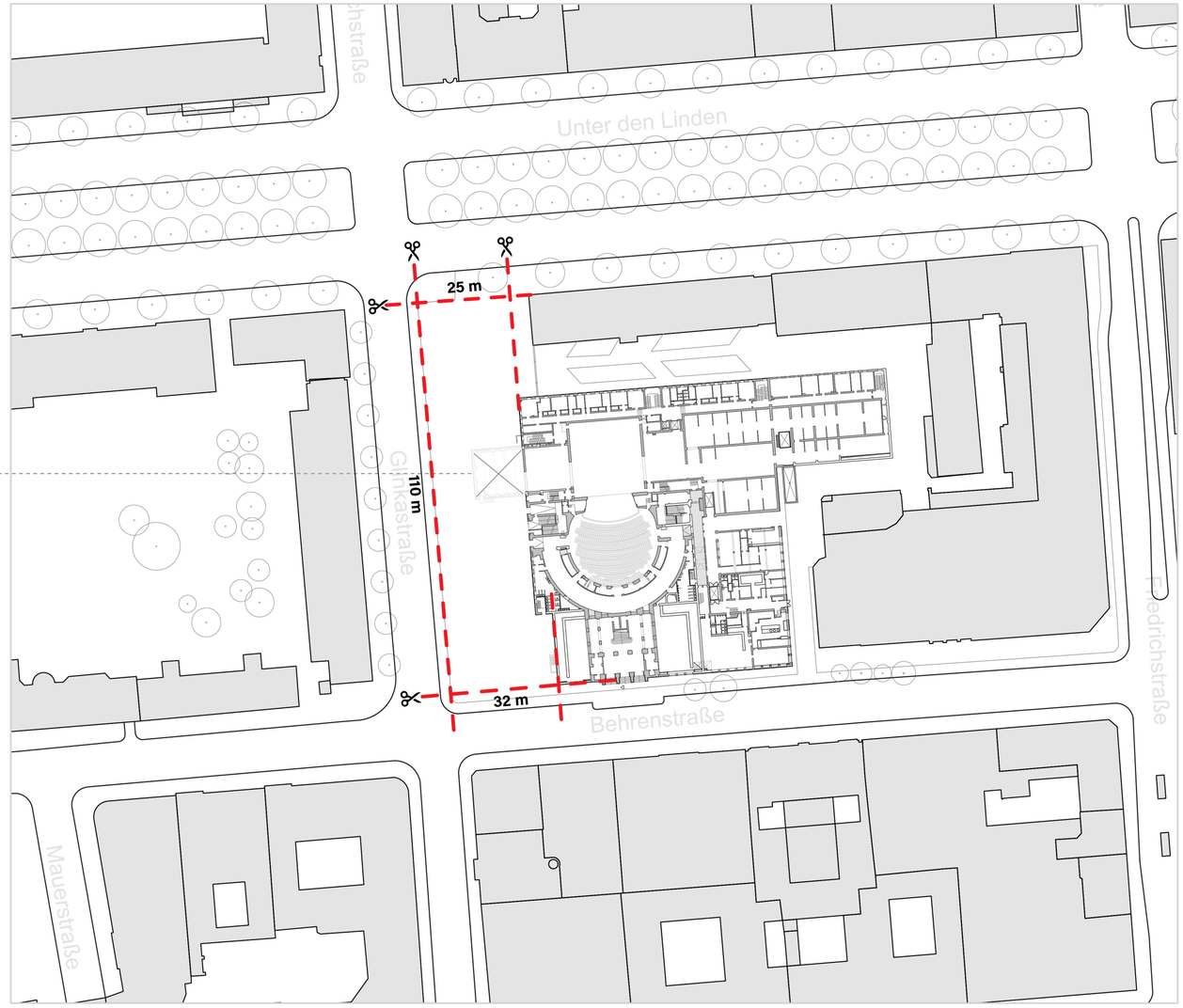


TRADITIONAL LAYOUT

Divided Back of House, Auditorium, Entrance and Support Spaces



DEMOLISH
A small Back of House extention of the theatre will get demolished to make space for the theatre



EXTENTION AREA
With Respect to the Context



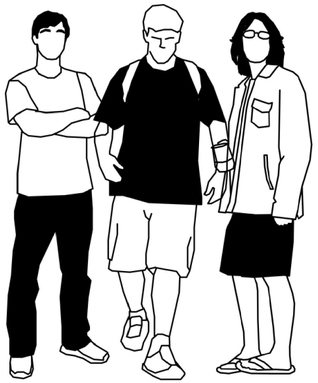
EMPLOYEE / PERFORMER

Someone that works or performs inside the building



VISITOR

Someone that uses the building as a visitor to the shows

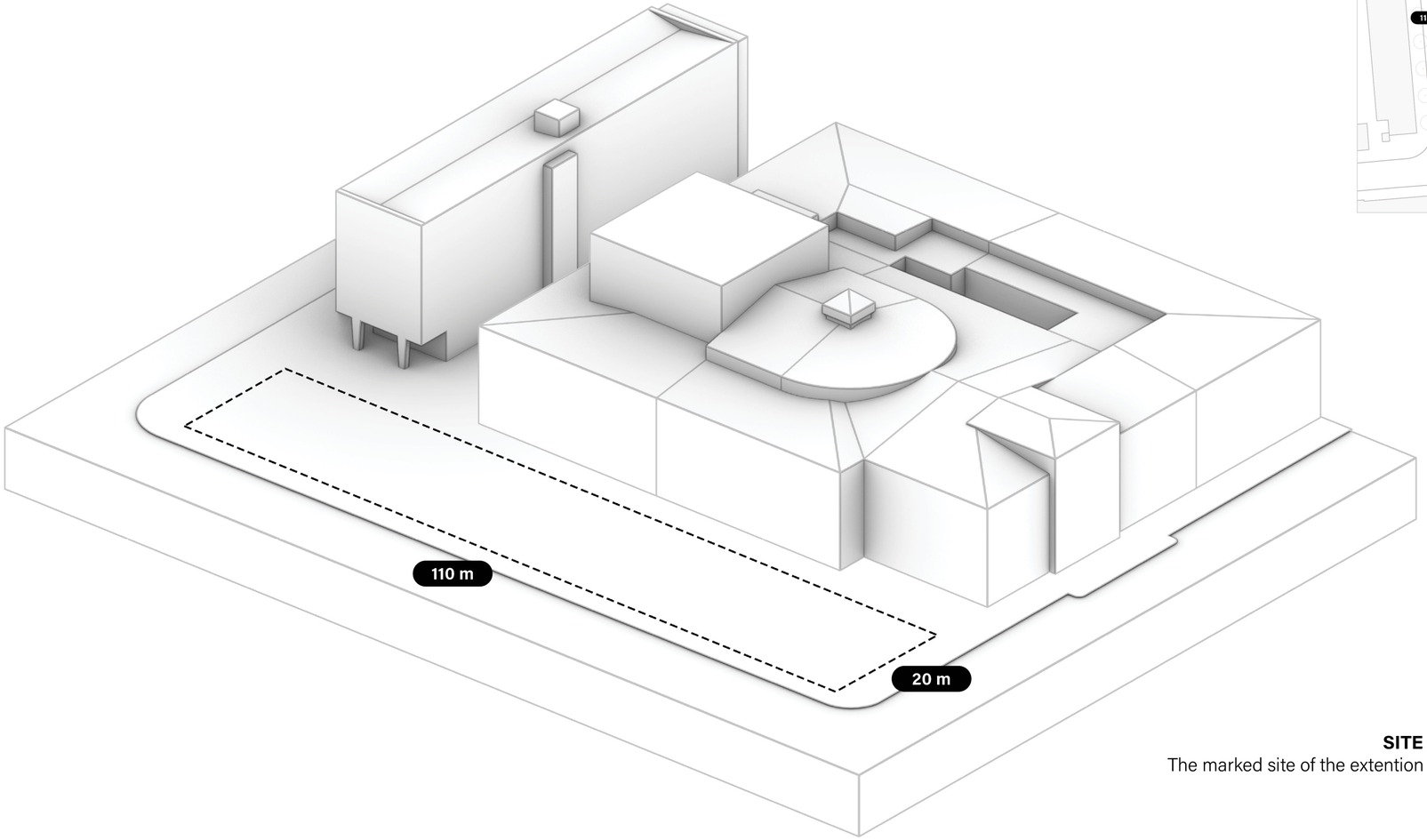


PEOPLE OF BERLIN

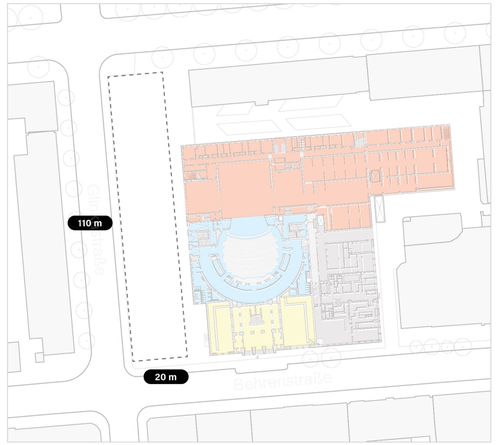
People that withnesses the building form afar

TARGET AUDIENCE

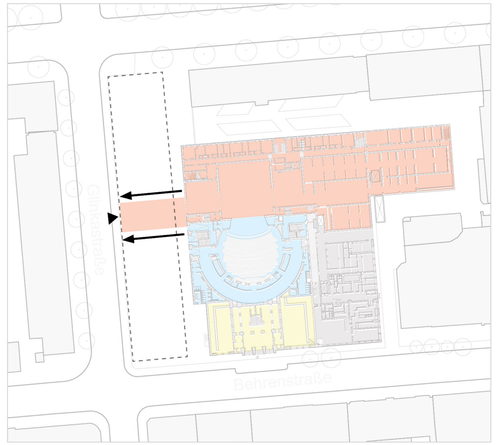
Most Important Users of the New Building



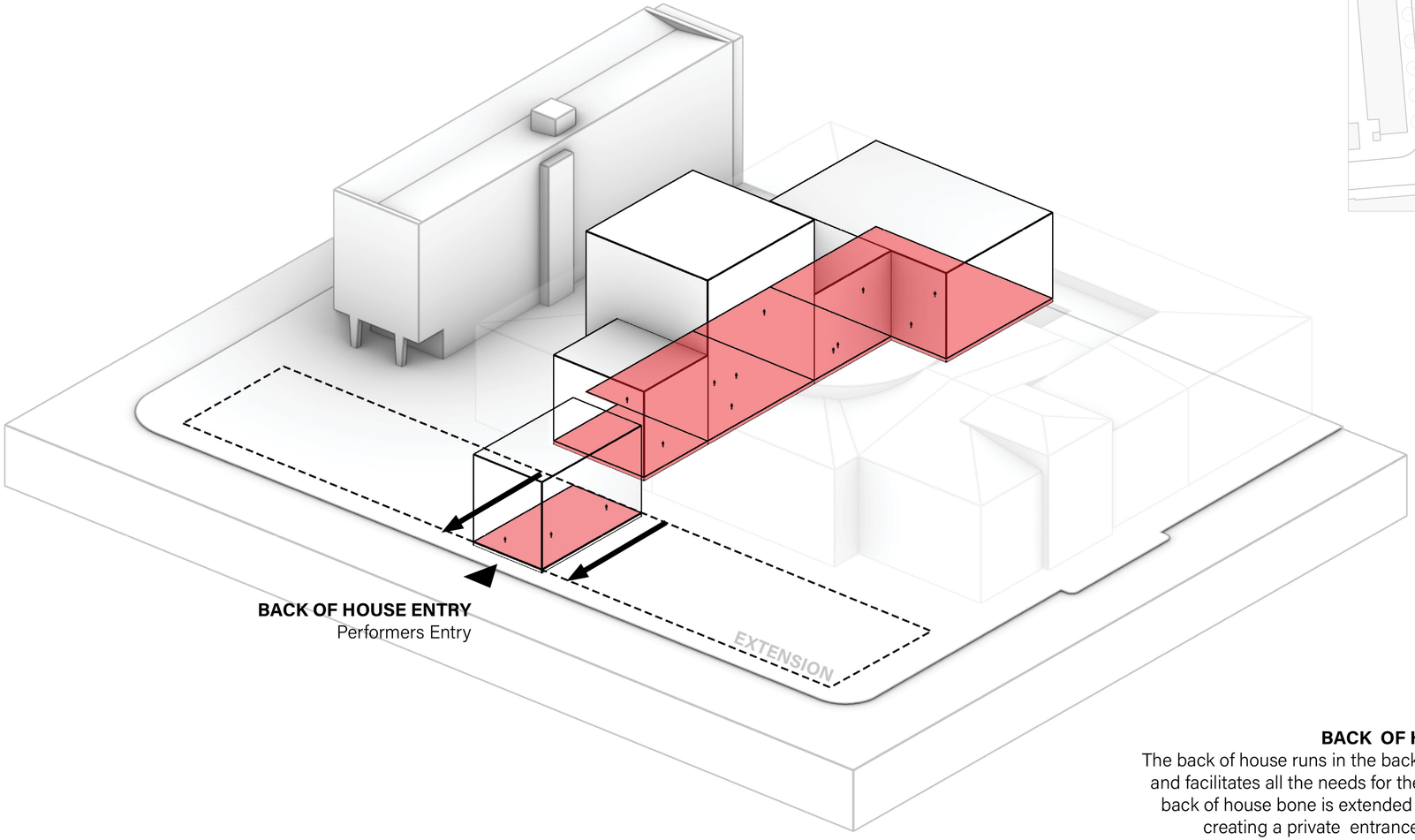
SITE OF THE PROJECT
The marked site of the extention next to the existing theatre



SITEPLAN
Program

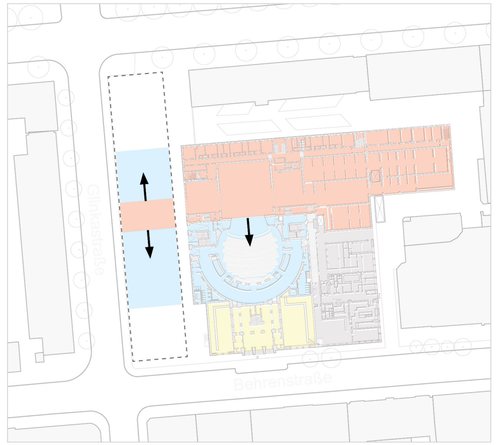


SITEPLAN
Program

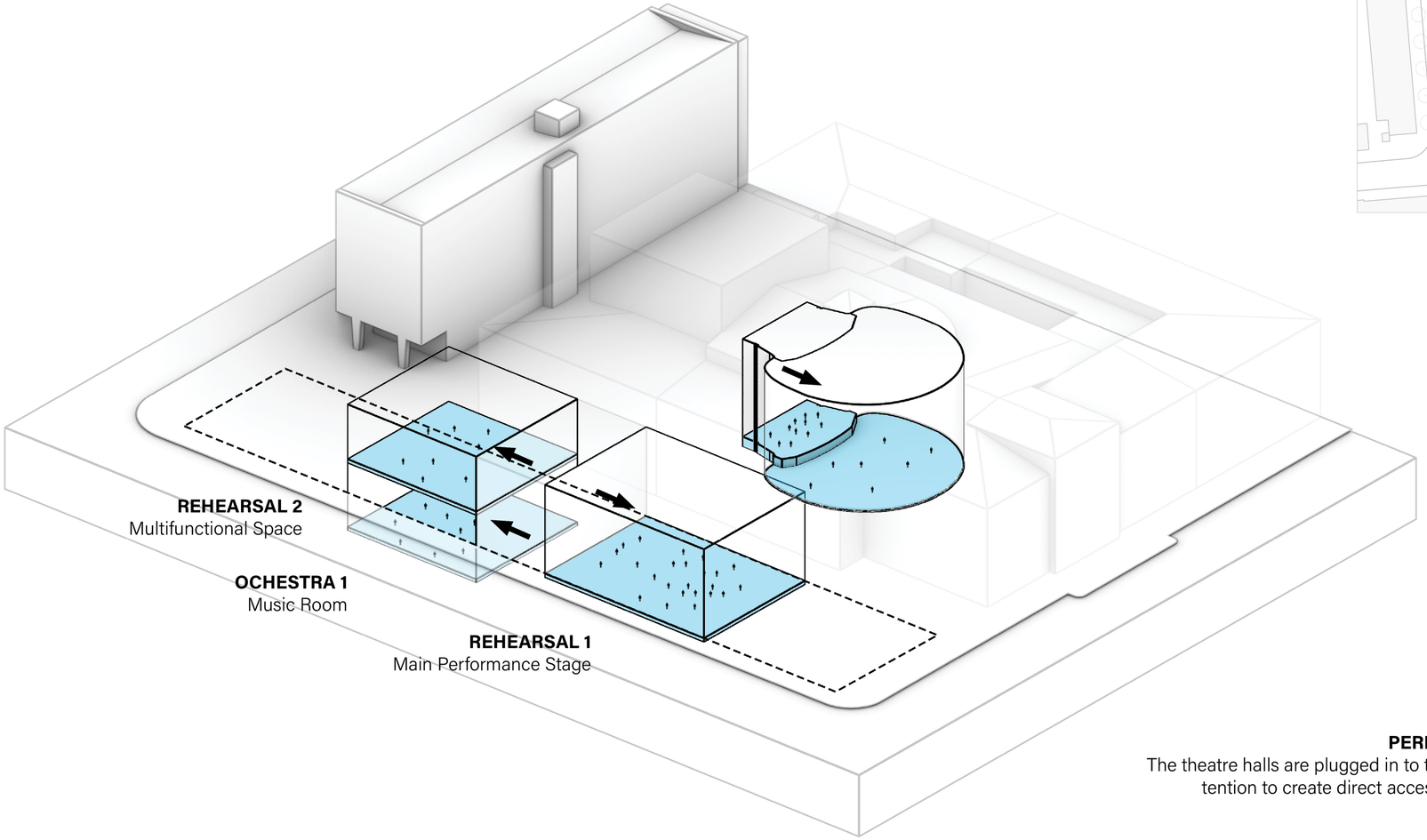


BACK OF HOUSE ENTRY
Performers Entry

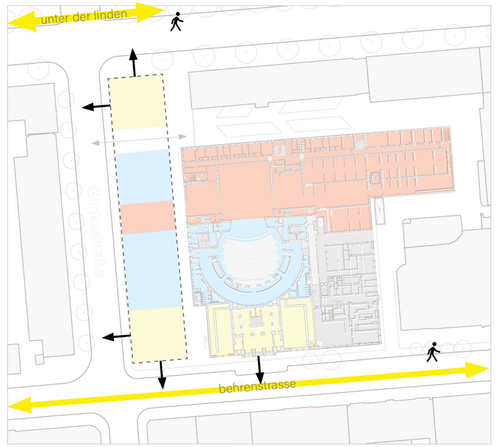
BACK OF HOUSE EXTENTION
The back of house runs in the back of the existing opera and facilitates all the needs for the performancers. This back of house bone is extended into the new building creating a private entrance at the Glinkastrasse.



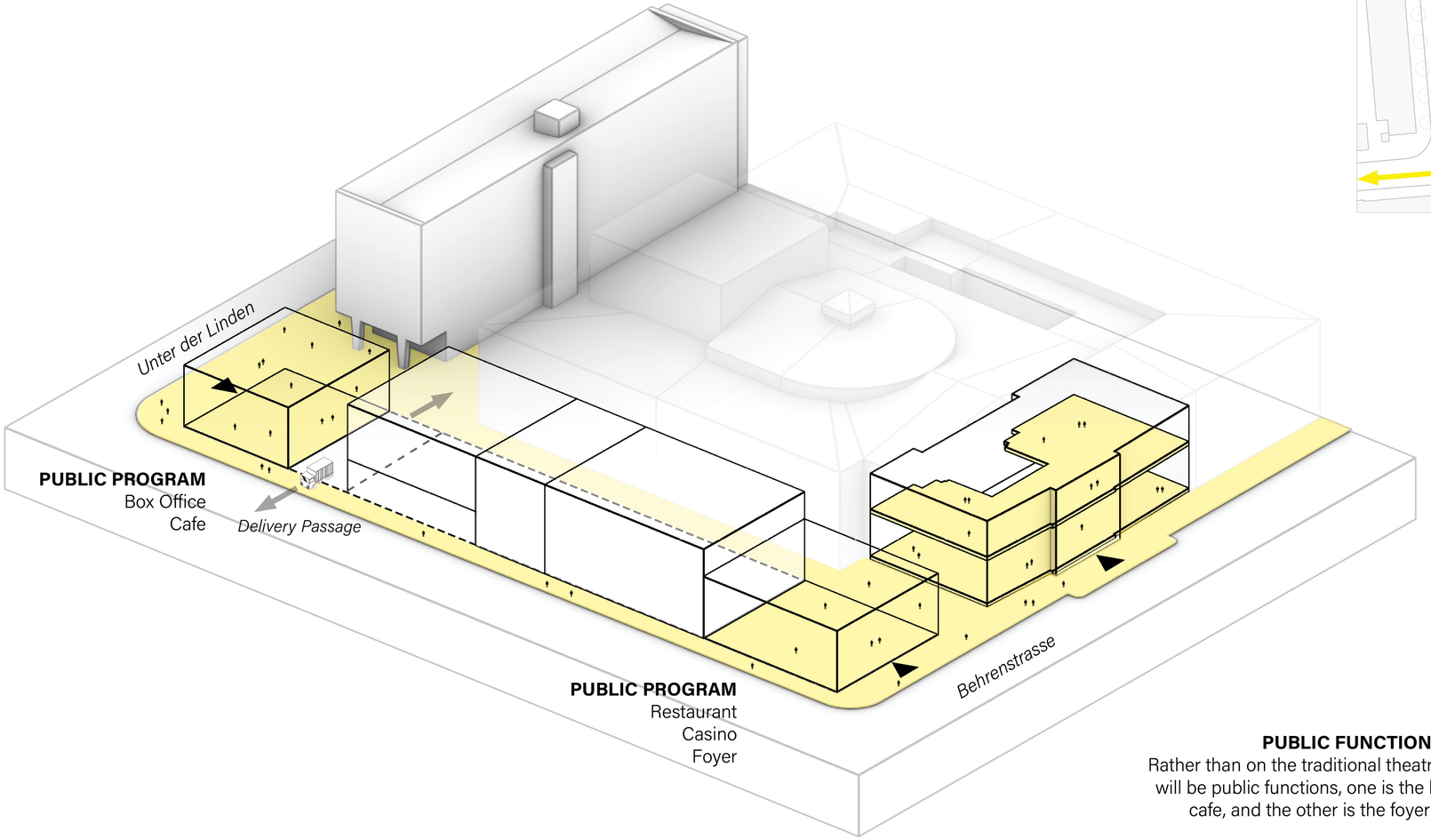
SITEPLAN
Program



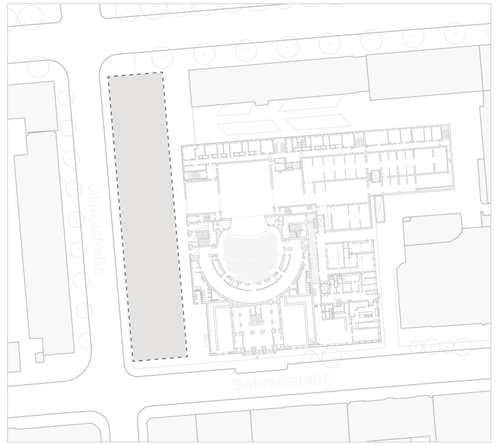
PERFORMANCE HALLS
The theatre halls are plugged in to the back of house extention to create direct access for the performers.



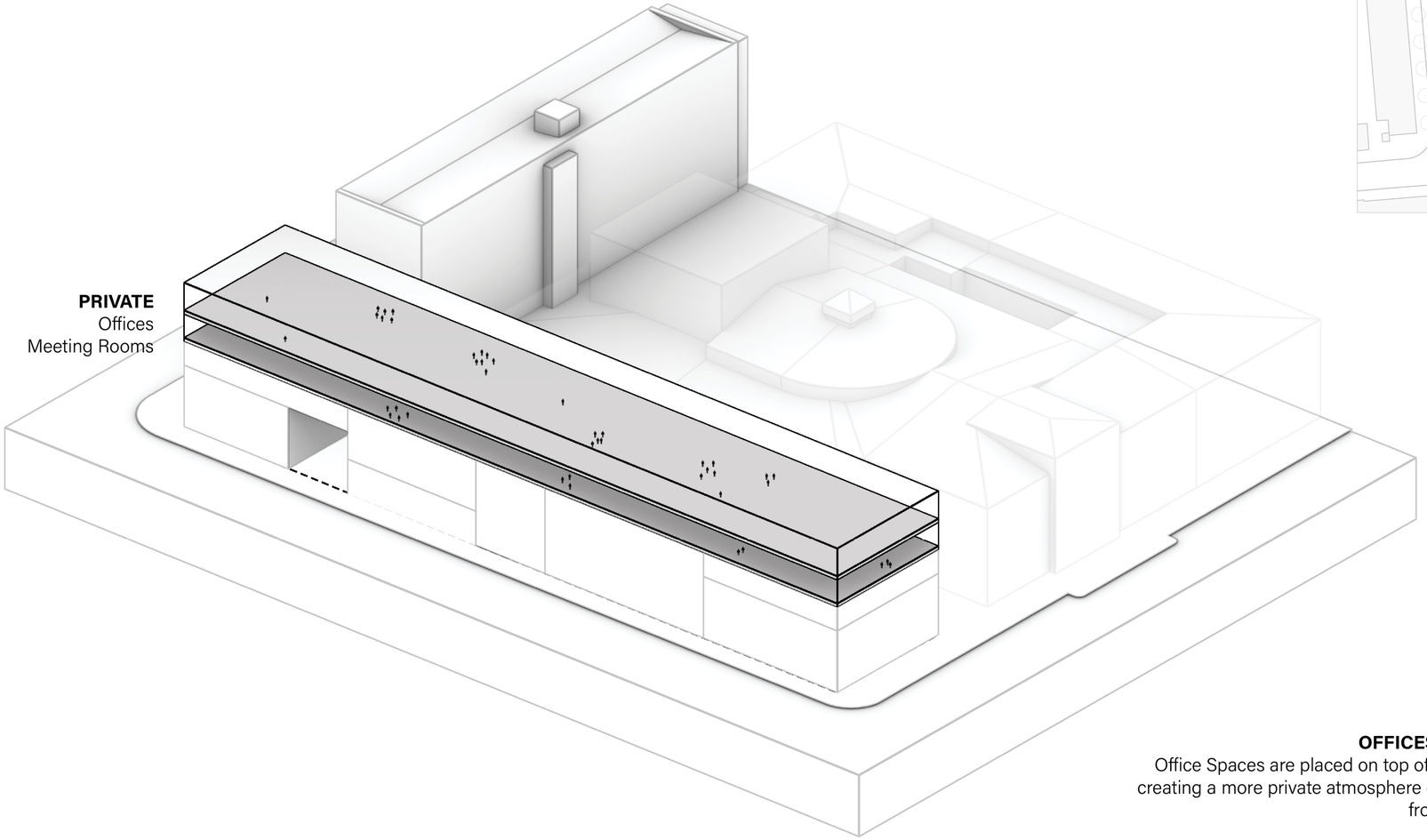
SITEPLAN
Program



PUBLIC FUNCTIONS ON EITHER SIDE
Rather than on the traditional theatre on each side there will be public functions, one is the box office and public cafe, and the other is the foyer including restaurant

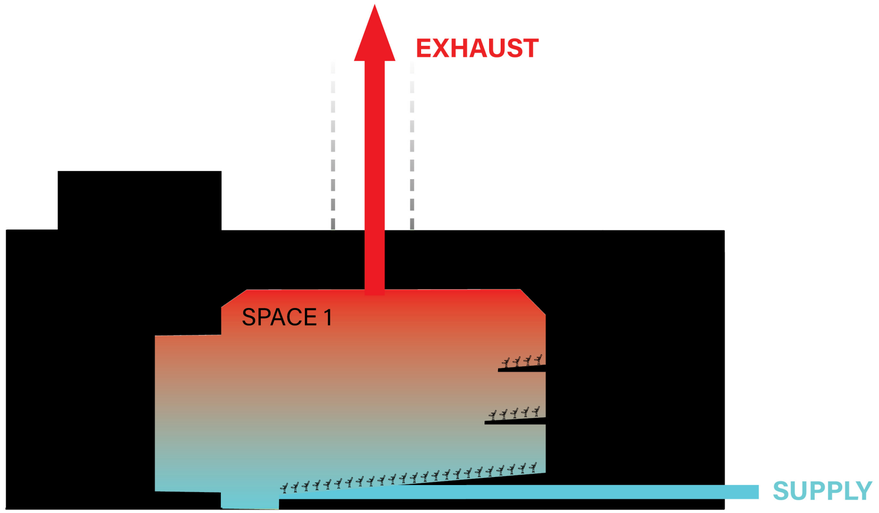


SITEPLAN
Program

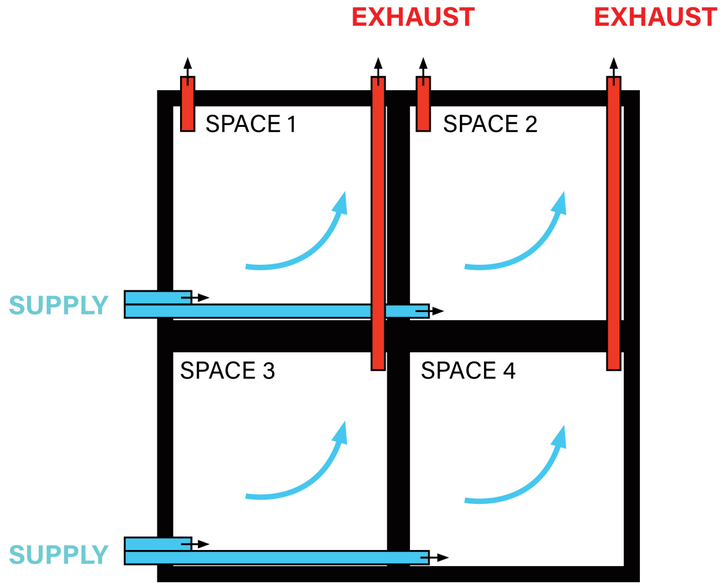


PRIVATE
Offices
Meeting Rooms

OFFICES PLACED ON TOP
Office Spaces are placed on top of the public functions, creating a more private atmosphere on those floors, away from the busy streetlife.

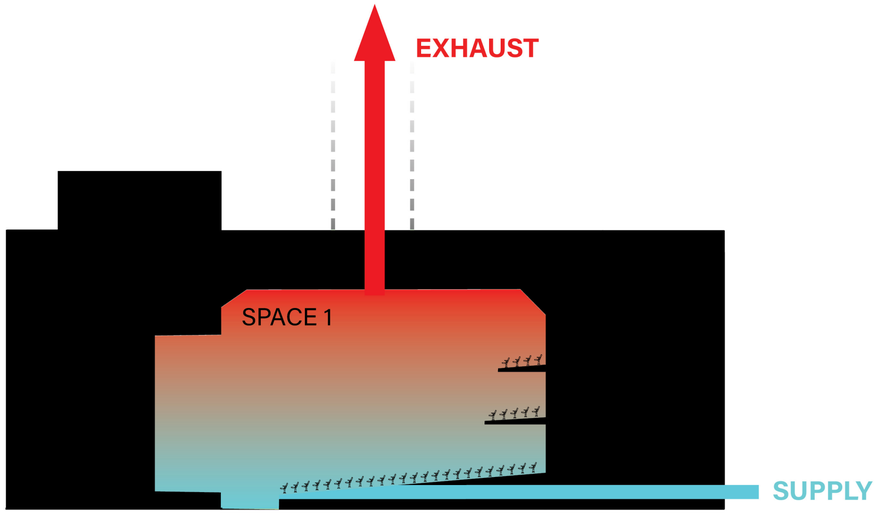


ONE SPACE
The researched method only covers one space



MULTIPLE SPACES
Individual shafts to regulate airflow

NATURAL VENTILATION SYSTEM
Direct Translation to Multiple Spaces



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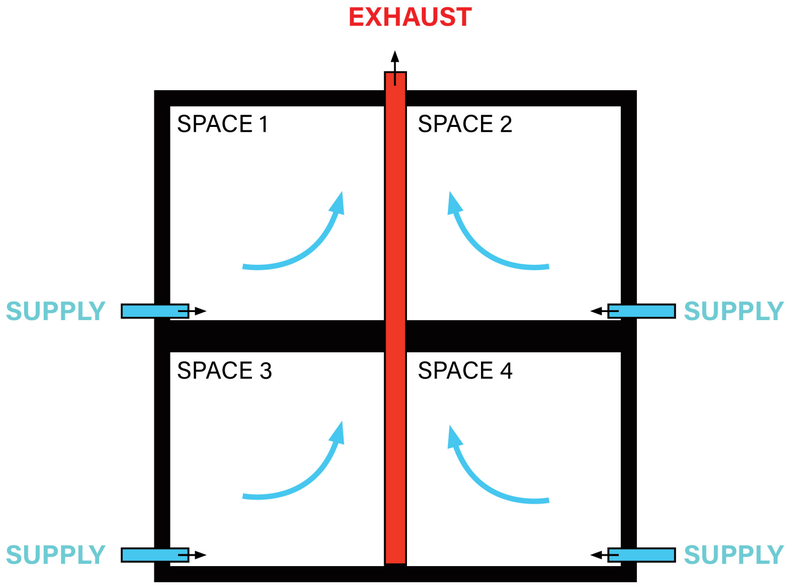
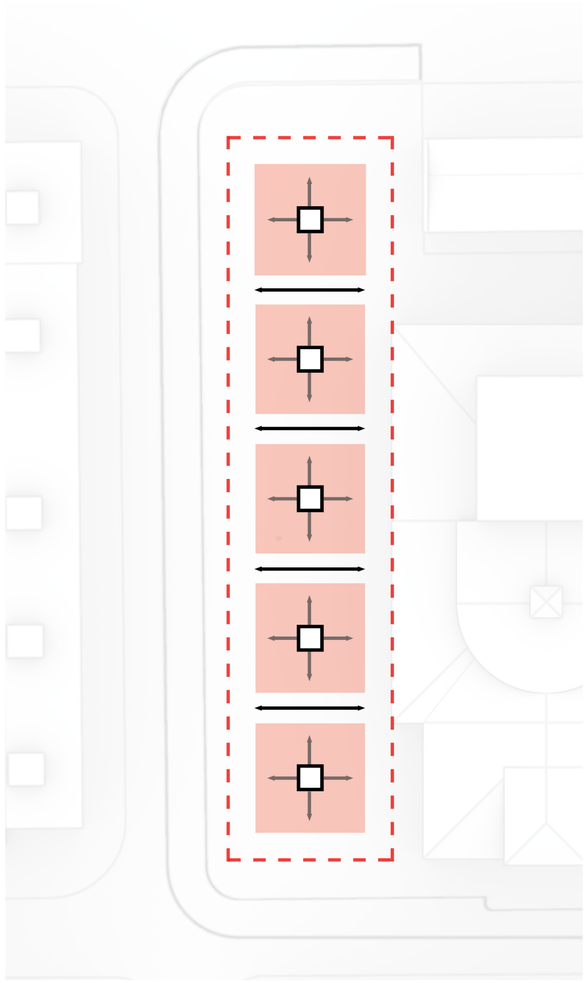
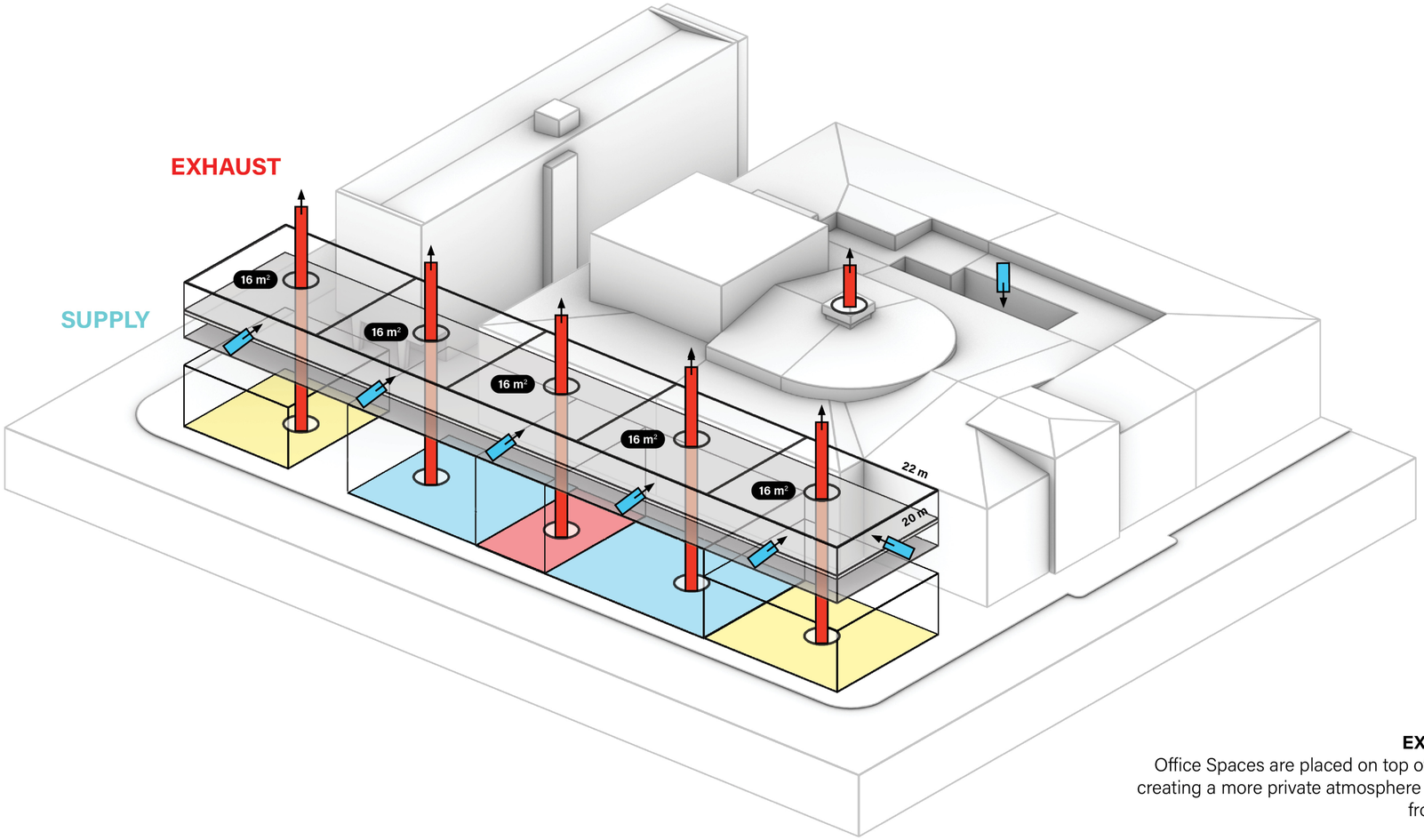


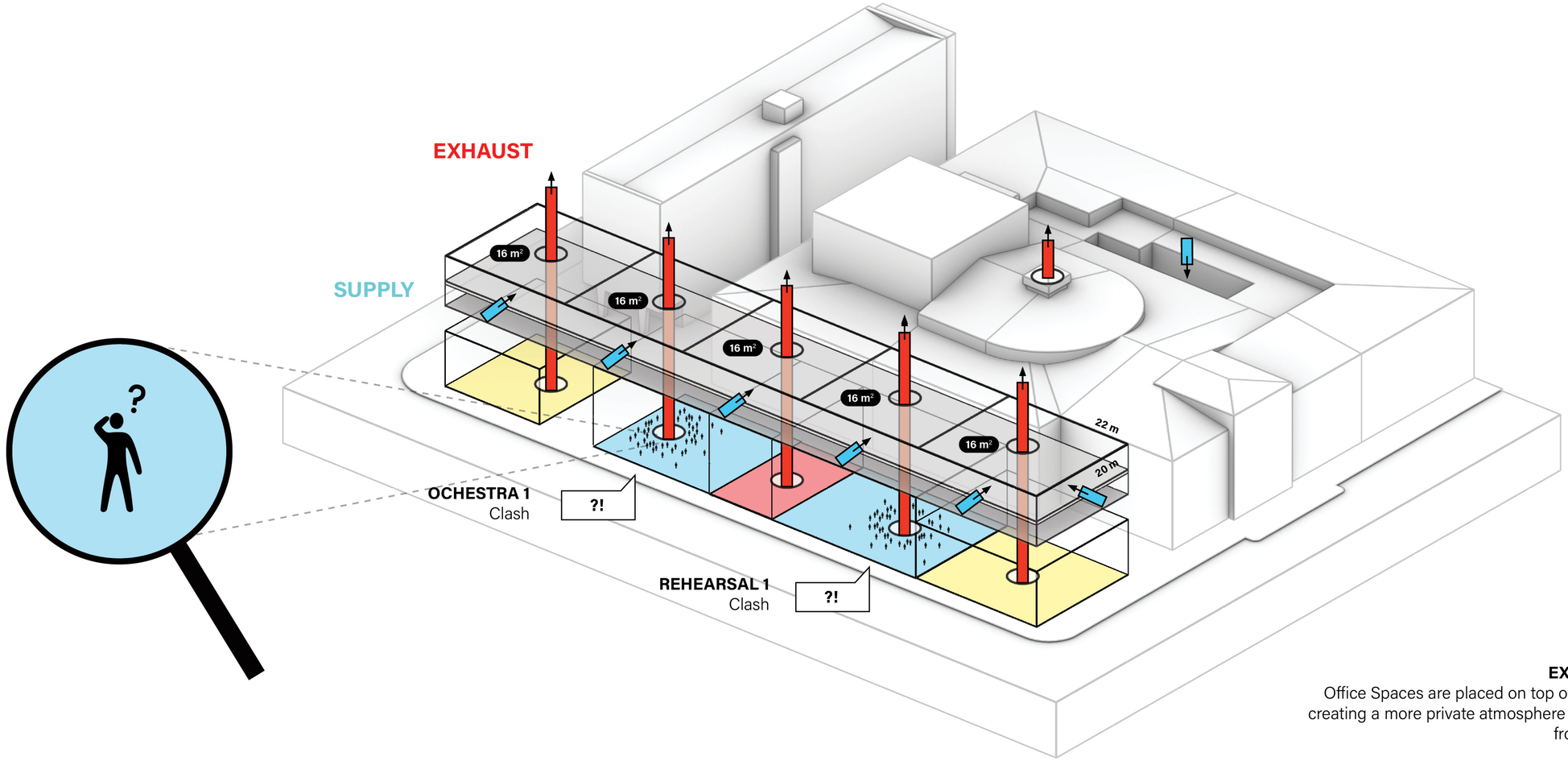
MULTIPLE SPACES
One central shaft and direct entry of air

NATURAL VENTILATION SYSTEM
Adjusted Model





EXHAUST OF THE AIR
Office Spaces are placed on top of the public functions, creating a more private atmosphere on those floors, away from the busy streetlife.



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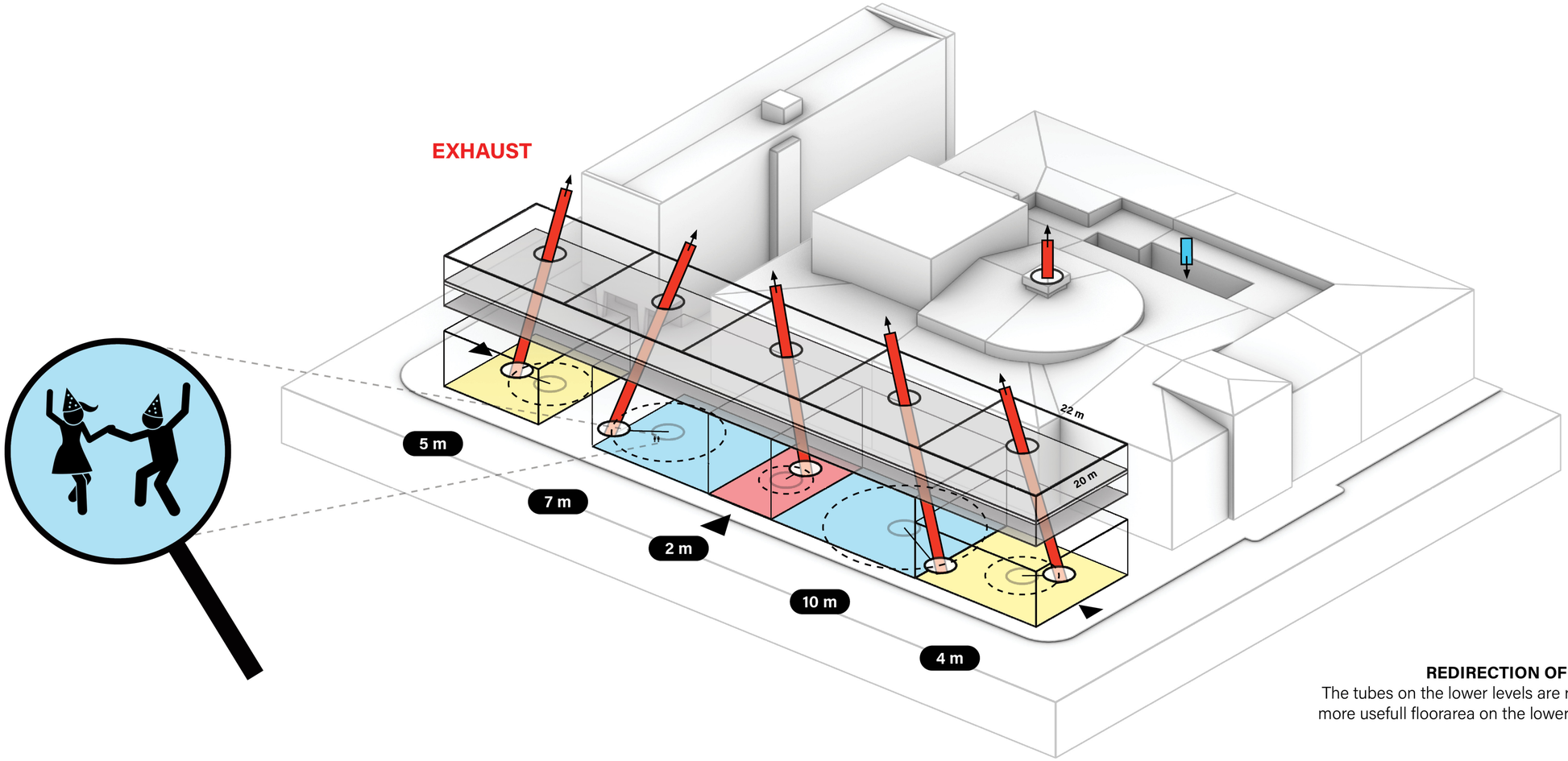
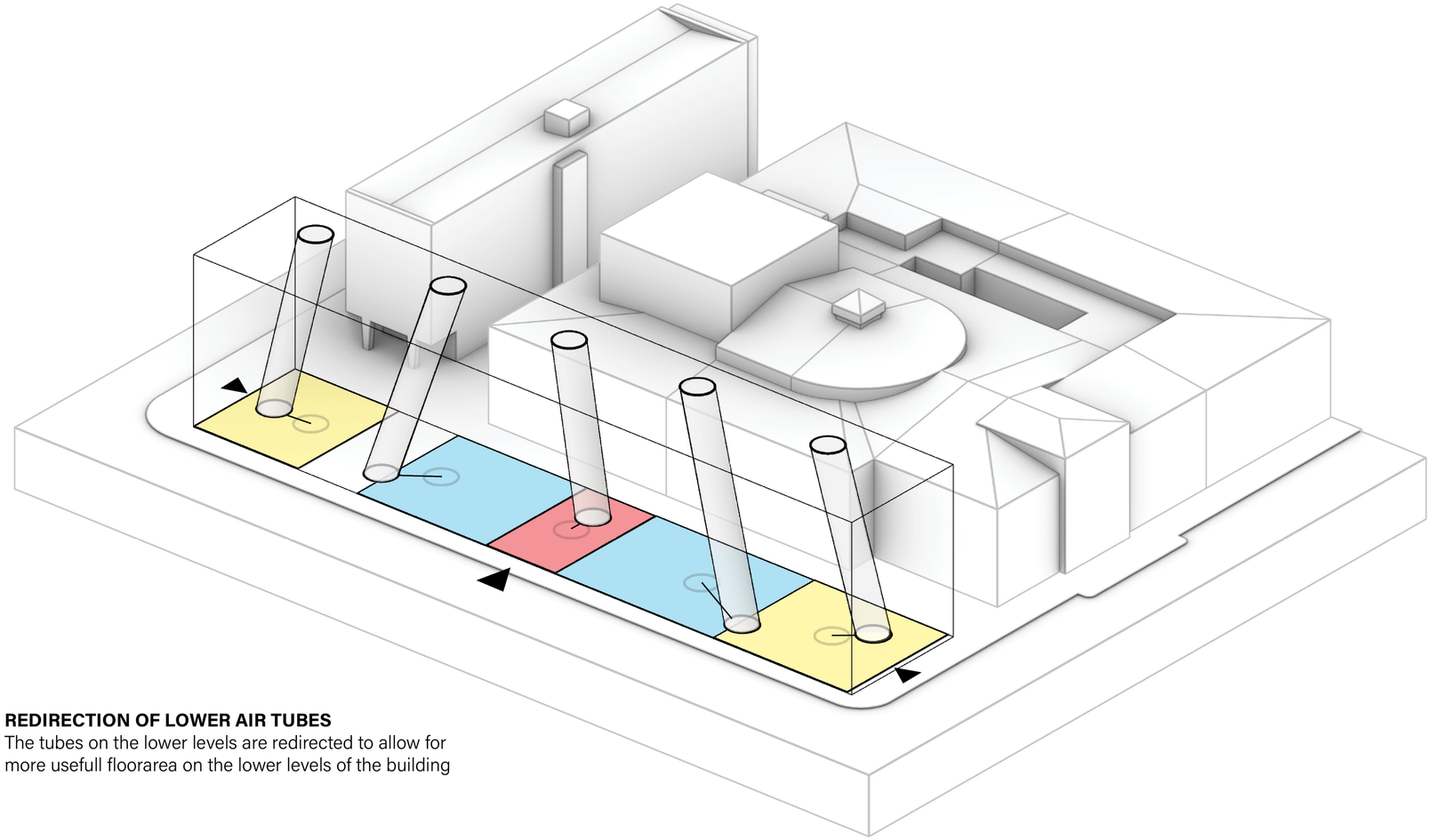


REDIRECTION OF LOWER AIR TUBES
The tubes on the lower levels are redirected to allow for more usefull floorarea on the lower levels of the building



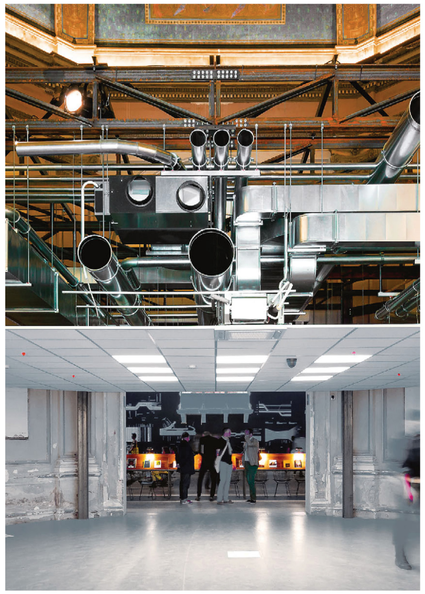
REDIRECTION OF LOWER AIR TUBES
The tubes on the lower levels are redirected to allow for more usefull floorarea on the lower levels of the building

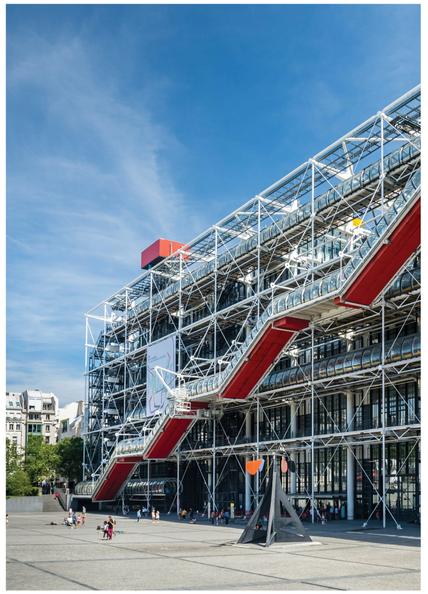


LIGHT BEAMS
The ventilation tubes are like light beams penetrating the volume of the building



Performance Hall, Komische Oper





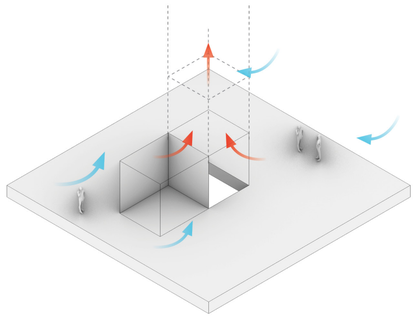
DISGUISED TECHNIQUE

Buildings Always Try to Hide Their Technical Aspects from the Public

CELEBRATE ~~TECHNICAL~~ SUSTAINABLE METHOD

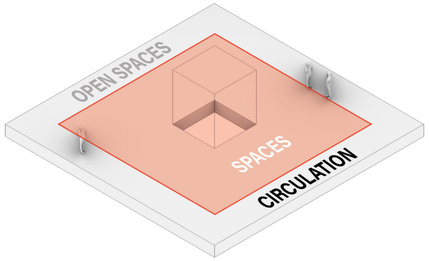
Celebrate Sustainable Interventions in Architecture

MULTIFUNCTIONAL TUBES



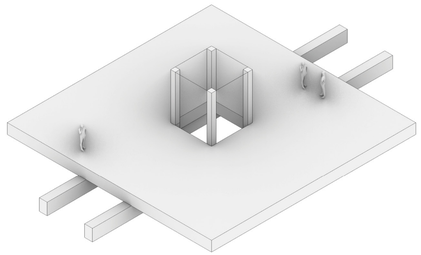
VENTILATION

The main function of the tubes are the ventilation of the spaces



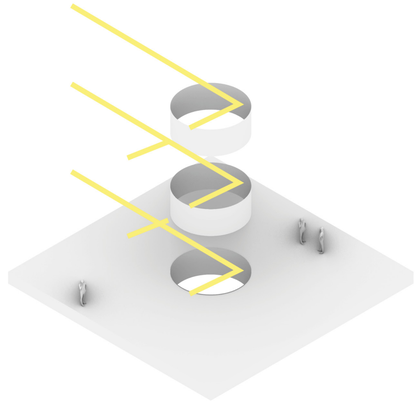
FLOORPLANNING

The location of the tubes can have influence on the floorplanning of the building



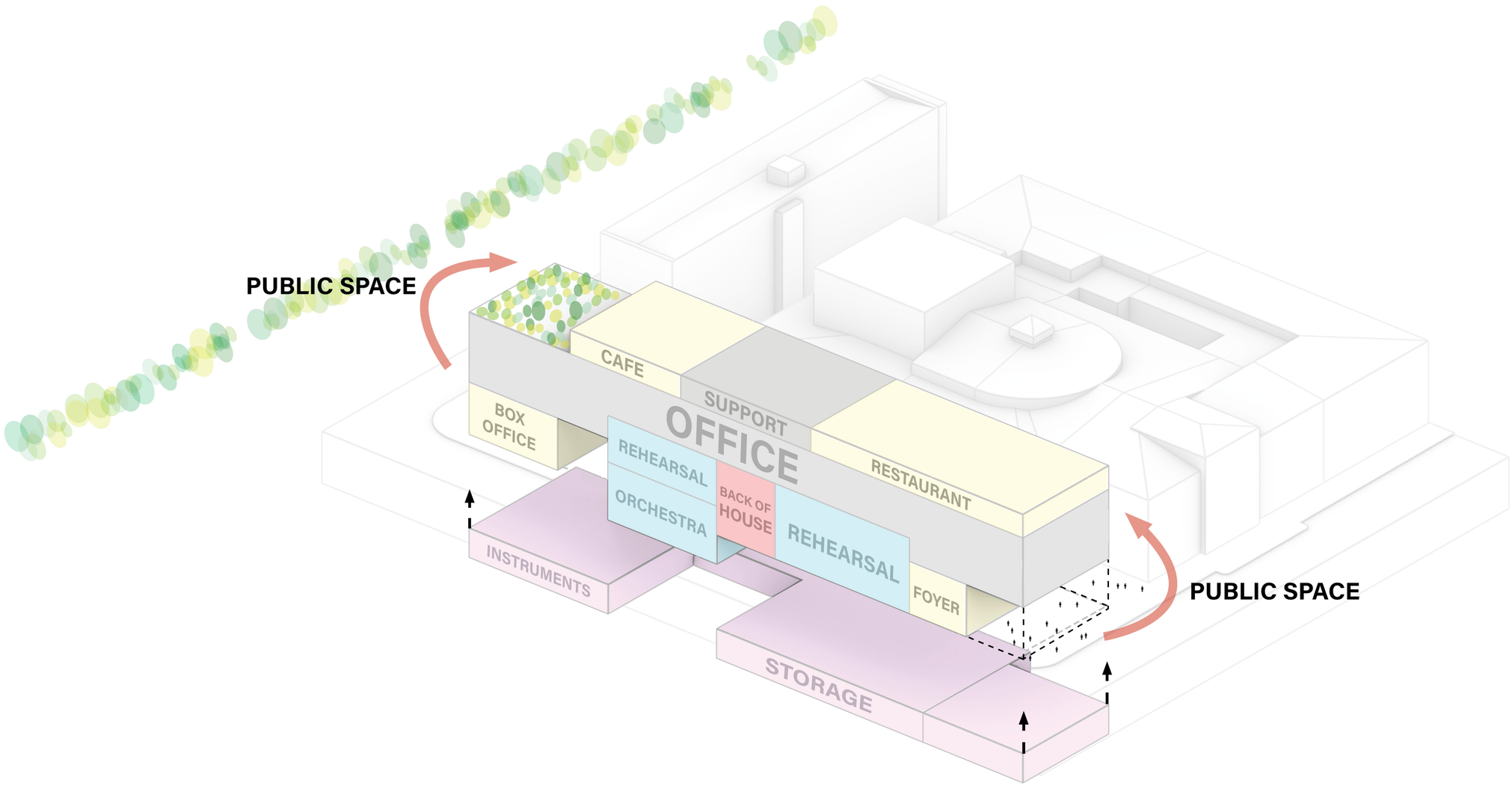
CONSTRUCTION

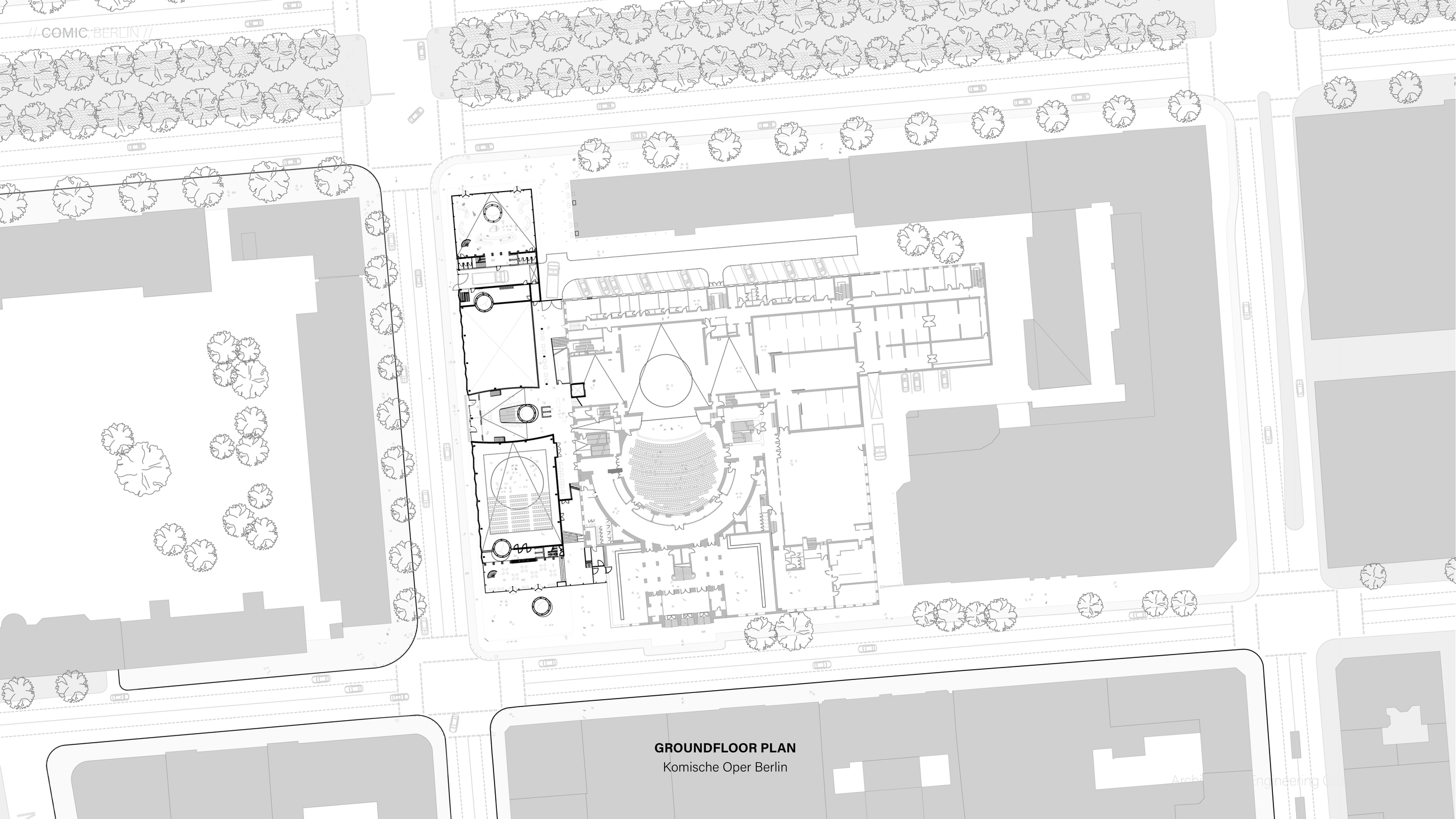
The tubes can play a role in the construction of the building, requiring little to no columns in the building, creating open floorplates



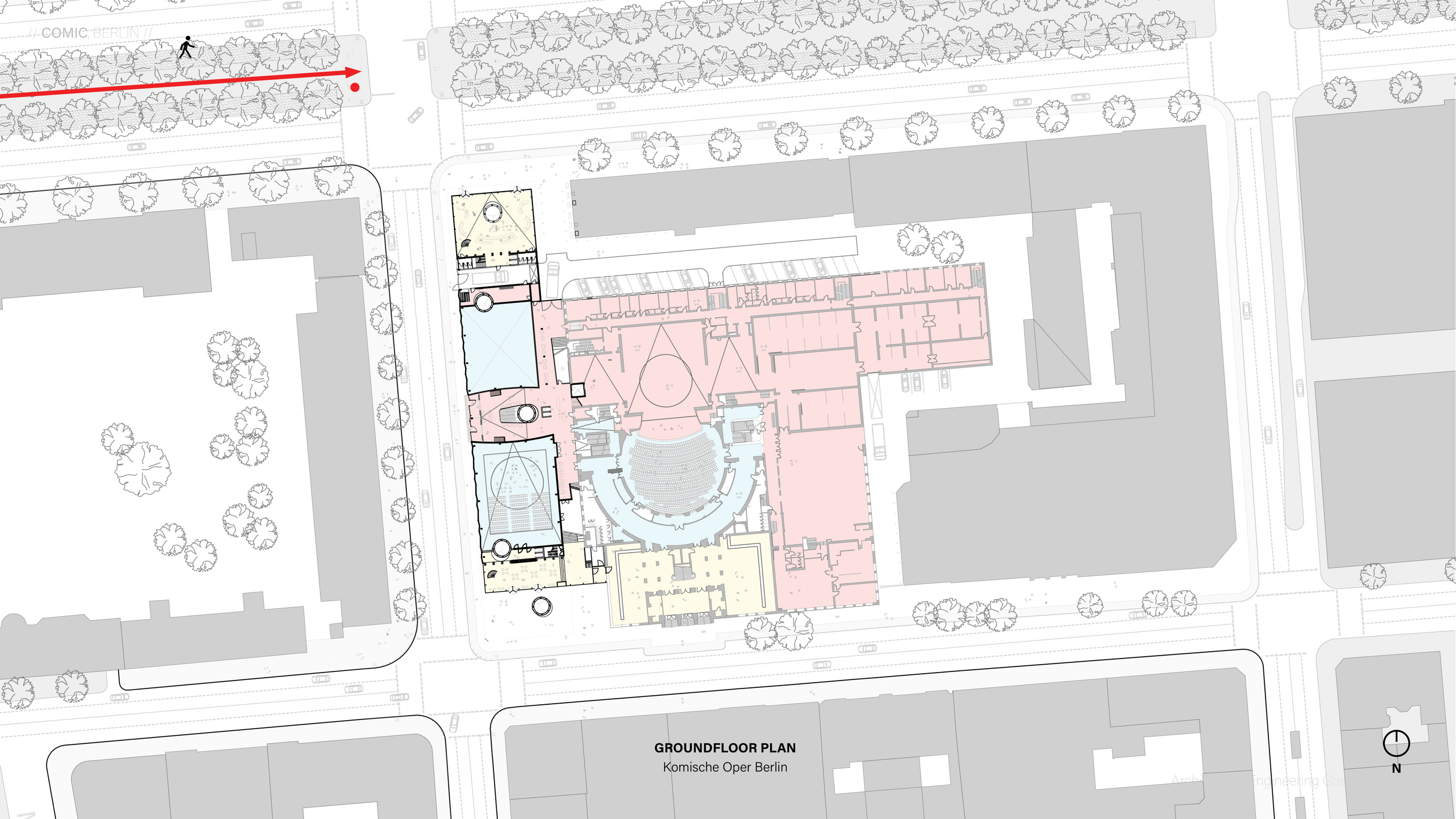
LIGHT

The hollow form of the tubes may allow for extra natural light to enter inside the building, or installed light can influence the light.


PUBLIC SPACE
CAFE
SUPPORT
OFFICE
BOX OFFICE
REHEARSAL
ORCHESTRA
BACK OF HOUSE
REHEARSAL
RESTAURANT
FOYER
INSTRUMENTS
STORAGE
PUBLIC SPACE



GROUNDFLOOR PLAN
Komische Oper Berlin



GROUNDFLOOR PLAN

Komische Oper Berlin



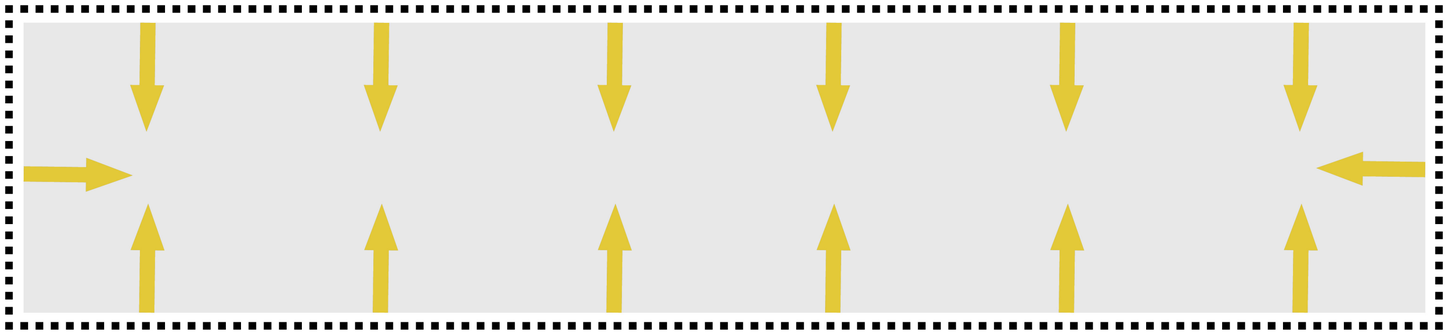
Theatre Extention, Unter Der Linden



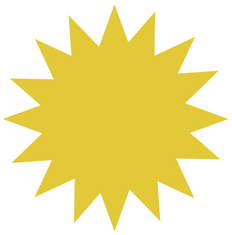
Box Office, Unter Der Linden



Theatre Extention, Unter Der Linden



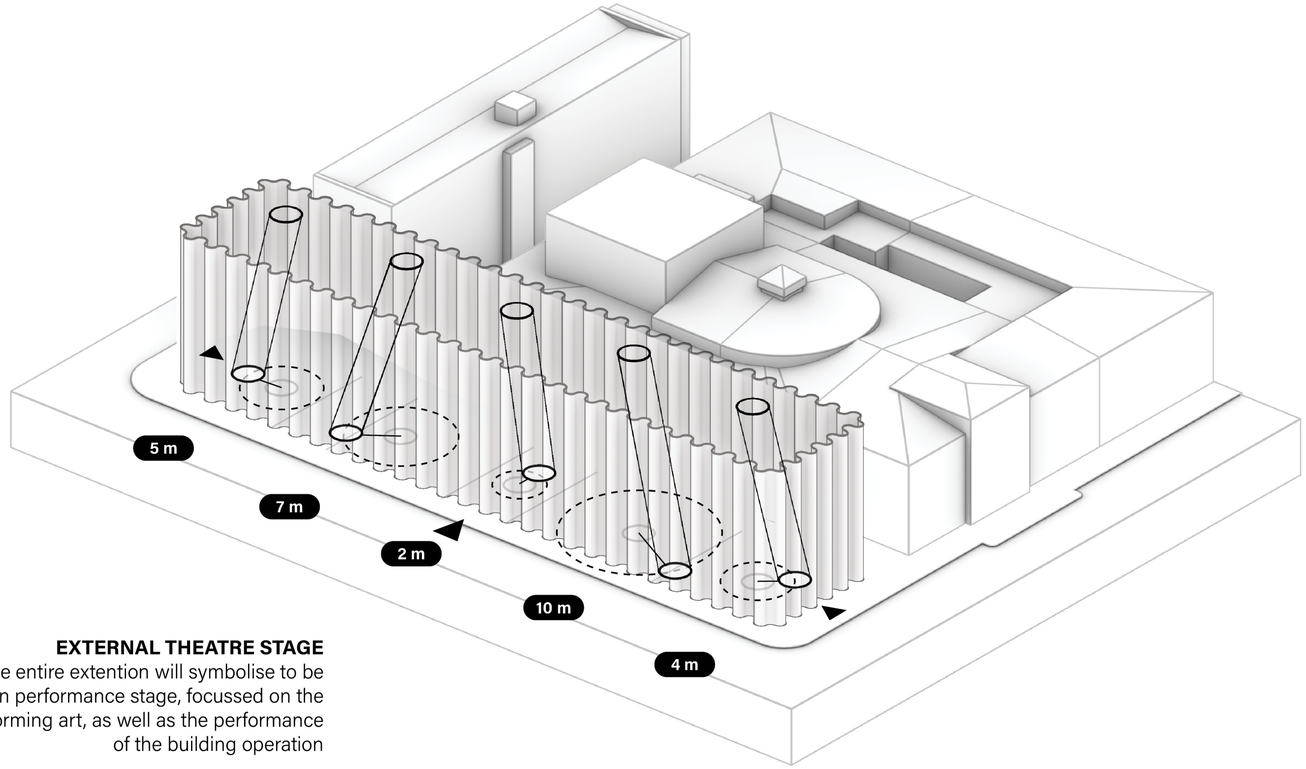
FACADE



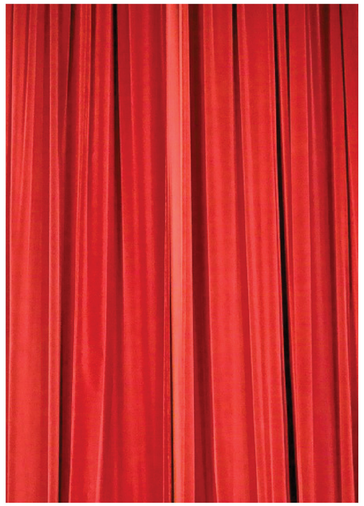
MAXIMIZE SUNLIGHT ENTRY



DECREASE ELECTRICITY FOR ELECTRICAL LIGHTING

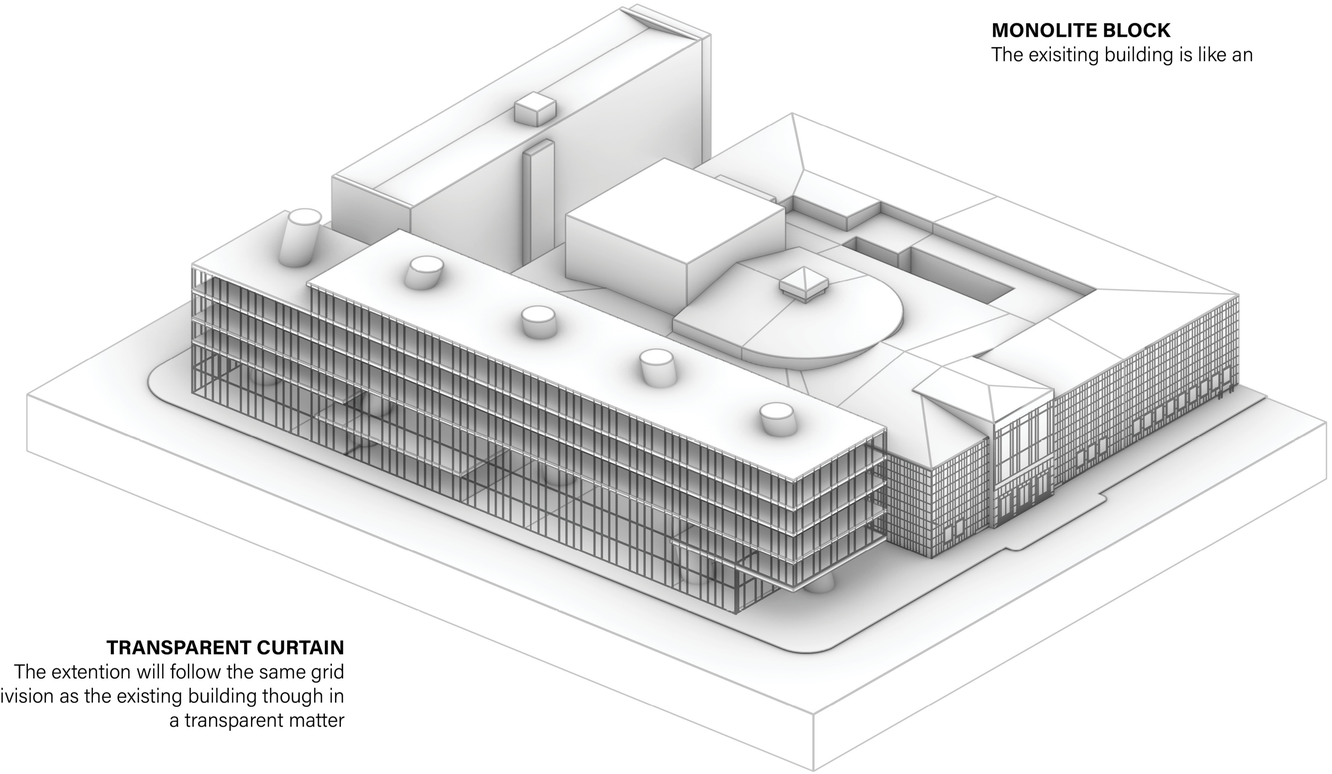


EXTERNAL THEATRE STAGE
The entire extention will symbolise to be an performance stage, focussed on the performing art, as well as the performance of the building operation



CURTAIN
The facade operates as a transparent curtain surrounding the new theatre

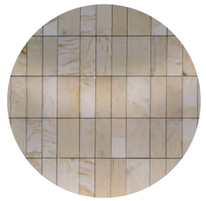
MONOLITE BLOCK
The exisiting building is like an



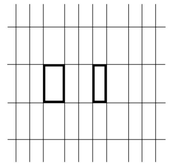
TRANSPARENT CURTAIN
The extention will follow the same grid division as the existing building though in a transparent matter



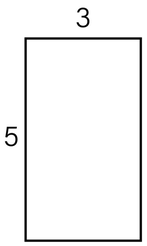
Komische Oper Berlin
Existing Building



Facade

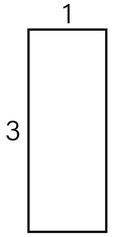


Grid



Panel 1

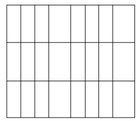
Ratio 5:3

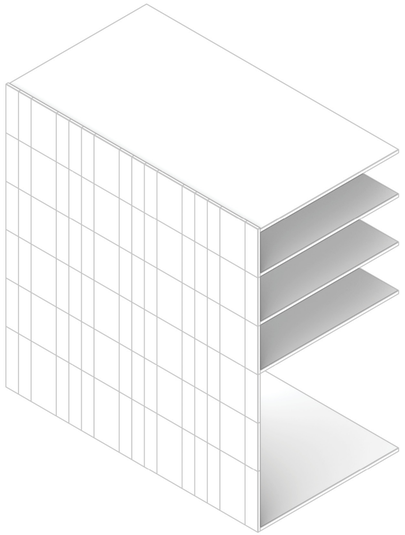


Panel 2

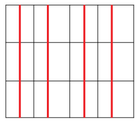
Ratio 3:1

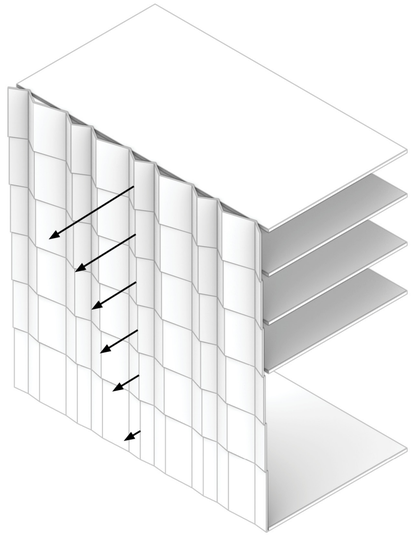
FACADE
Reference



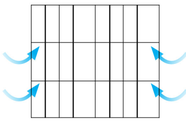


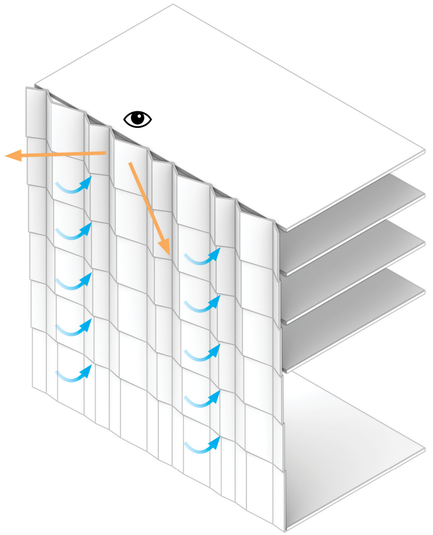
PLAIN FACADE
Reference to Existing Building - Grid





PULL OUT
Step by Step Extention of Facade Edges





ALLOW AIR AND VISUAL
Ventilation Entry + Extended View Direction



NO VENTILATION ENTRY

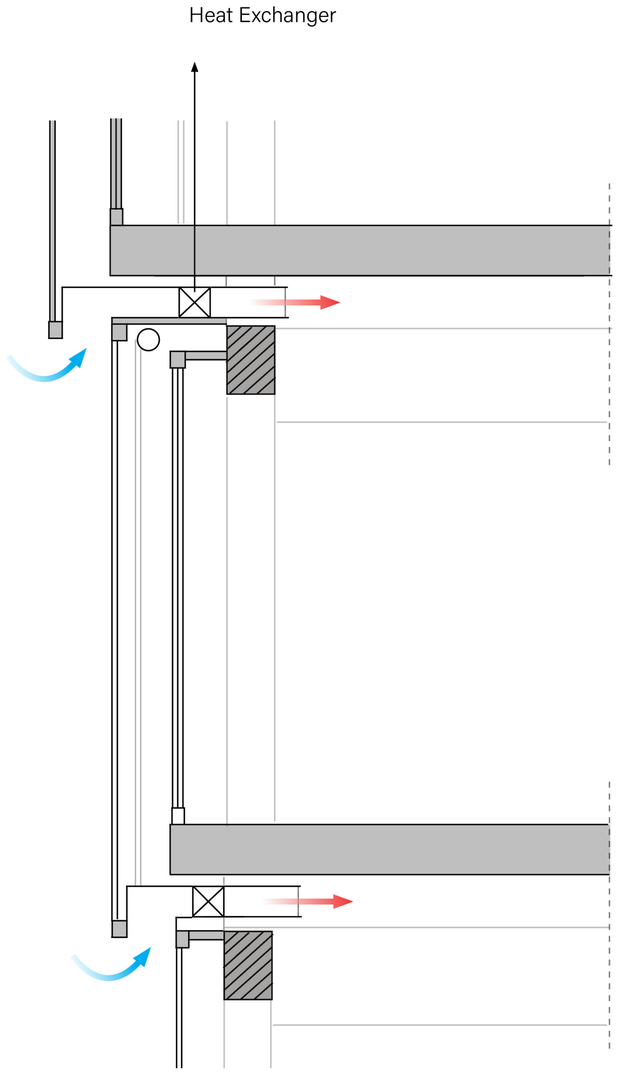


VENTILATION ENTRY

FACADE
Concept

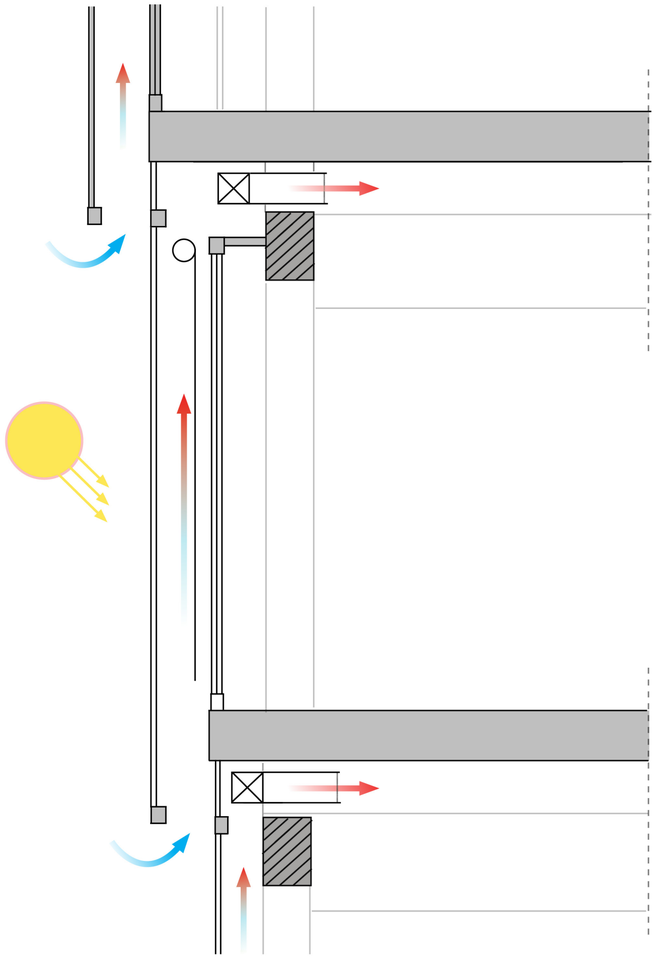


FACADE
Pedestrian View



CONCEPT FACADE DETAIL
Climate Facade

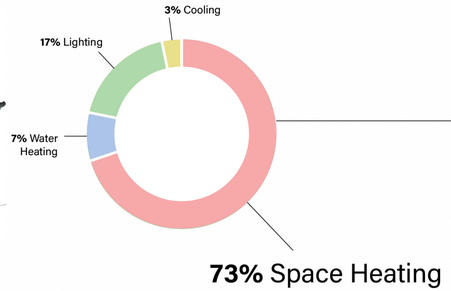




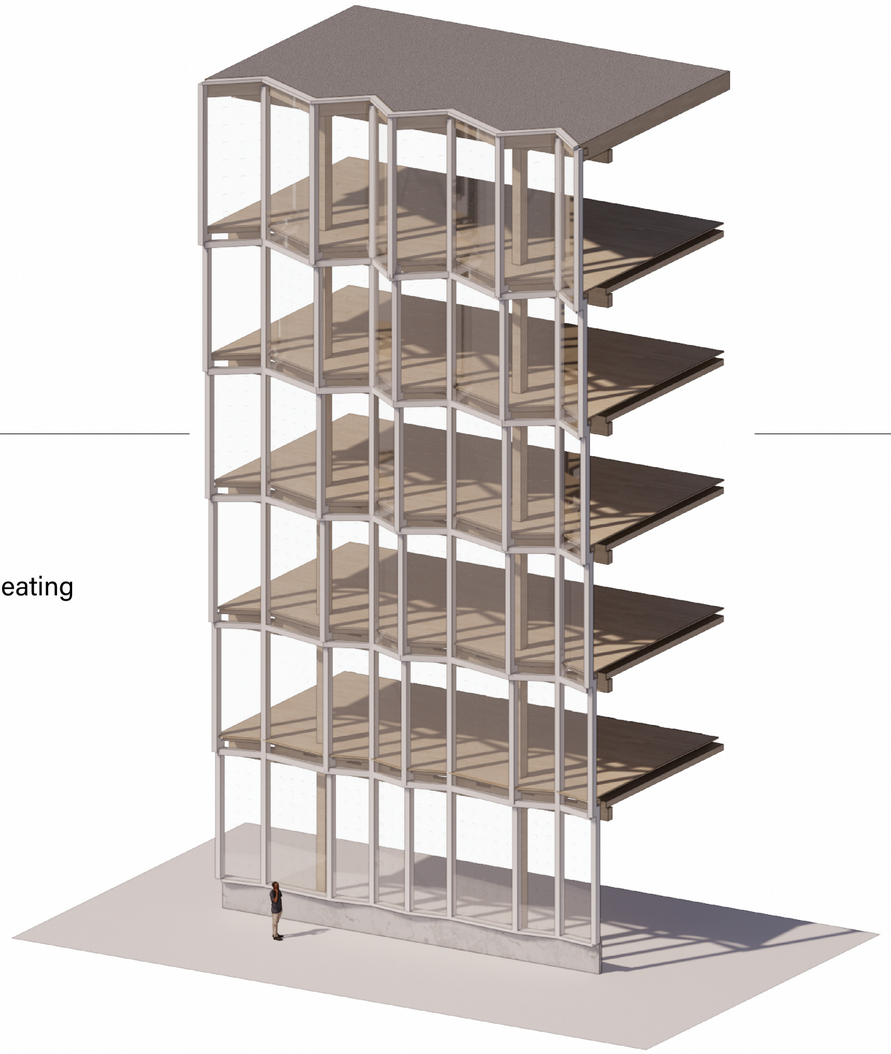
CONCEPT FACADE DETAIL
Climate Facade







ENERGY REQUIREMENT
Non Residential Buildings - Central European Climate



GLASS FACADE
Curtain Wall Facade

	January	February	March	April	May	June	July	August	Sept	October	Nov	Dec
1	1,5	-0,5	4,2	6,3	10,7	15,2	16,8	16,2	13,1	9,2	3,8	2,0
2	1,4	-0,6	4,0	5,9	10,3	14,7	16,3	15,8	12,7	8,9	3,7	1,9
3	1,4	-0,7	3,8	5,4	10,0	14,3	15,9	15,3	12,4	8,7	3,6	1,9
4	1,1	-1,0	3,7	5,0	9,8	13,7	15,5	15,0	12,2	8,5	3,5	2,1
5	1,2	-1,1	3,5	4,7	9,5	13,7	15,1	14,7	12,0	8,2	3,2	2,1
6	1,1	-1,1	3,3	4,7	10,3	14,4	15,4	14,6	12,1	7,9	3,1	2,1
7	1,1	-1,2	3,1	5,2	11,5	15,3	16,3	15,3	12,2	7,9	3,0	2,0
8	1,2	-1,2	3,3	6,6	12,8	16,3	17,2	16,4	13,1	8,2	2,9	2,1
9	1,3	-0,7	4,0	7,8	14,0	17,2	18,2	17,6	14,2	9,0	3,2	2,1
10	1,5	-0,2	4,9	8,9	15,1	18,1	19,5	18,7	15,2	10,0	3,7	2,2
11	2,0	0,6	5,8	9,8	16,1	19,1	20,4	19,8	16,1	10,7	4,5	2,4
12	2,6	1,2	6,9	10,4	16,7	19,8	20,9	20,4	17,1	11,6	5,4	2,8
13	2,9	1,7	7,4	11,0	17,2	20,6	21,8	21,2	17,9	12,4	6,1	3,2
14	3,1	2,0	7,7	11,6	17,7	21,1	22,3	21,7	18,5	12,9	6,4	3,3
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16	2,9	2,1	8,1	11,7	18,0	21,2	23,0	22,1	18,4	13,0	6,1	3,3
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21	1,8	0,5	5,6	8,7	14,1	17,5	19,4	19,0	15,0	10,3	4,5	2,3
22	1,6	0,3	5,5	7,9	13,4	17,0	18,7	18,2	14,3	9,9	4,3	2,3
23	1,5	0,1	4,9	7,3	12,4	16,4	17,9	17,5	13,7	9,7	4,2	2,2
24	1,4	-0,1	4,6	6,8	11,9	15,7	17,4	17,0	13,3	9,4	3,9	2,1

SEASONAL TEMPERATURES
Berlin, Germany

	January	February	March	April	May	June	July	August	Sept	October	Nov	Dec
1	1,5	-0,5	4,2	6,3	10,7	15,2	16,8	16,2	13,1	9,2	3,8	2,0
2	1,4	-0,6	4,0	5,9	10,3	14,7	16,3	15,8	12,7	8,9	3,7	1,9
3	1,4	-0,7	3,8	5,4	10,0	14,3	15,9	15,3	12,4	8,7	3,6	1,9
4	1,1	-1,0	3,7	5,0	9,8	13,7	15,5	15,0	12,2	8,5	3,5	2,1
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6	1,1	-1,1	3,3	4,7	10,1	14,4	15,4	14,6	12,1	7,9	3,1	2,1
7	1,1	-1,2	3,1	5,2	11,5	15,3	16,3	15,3	12,2	7,9	3,0	2,0
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11	2,0	0,6	5,8	9,8	16,1	19,1	20,4	19,8	16,1	10,7	4,5	2,4
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13	2,9	1,7	7,4	11,0	17,2	20,6	21,8	21,2	17,9	12,4	6,1	3,2
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22	1,6	0,3	5,5	7,9	13,4	17,0	18,7	18,2	14,3	9,9	4,3	2,3
23	1,5	0,1	4,9	7,3	12,4	16,4	17,9	17,5	13,7	9,7	4,2	2,2
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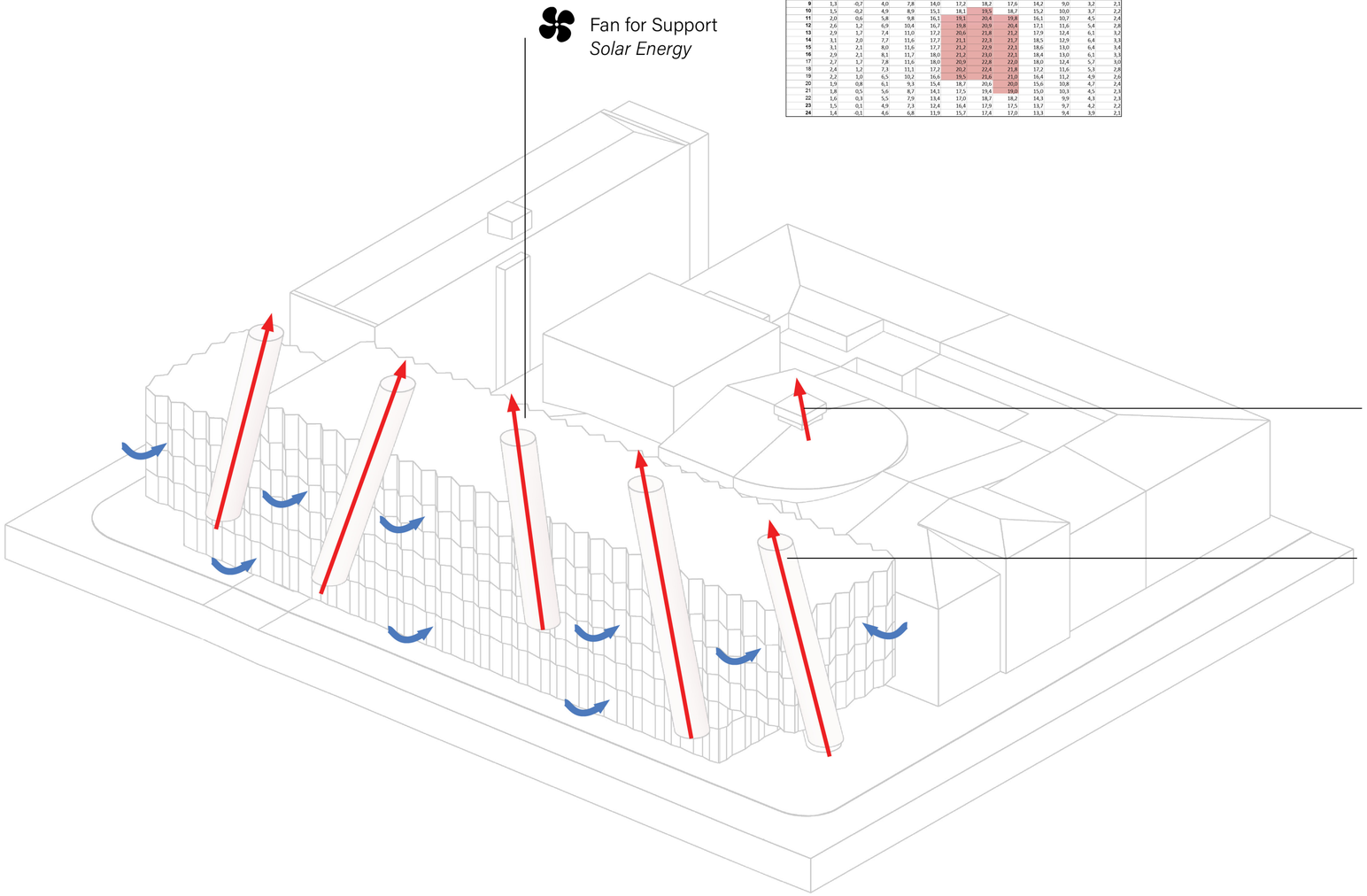

CLIMATE DESIGN

Komische Oper Berlin

	January	February	March	April	May	June	July	August	Sept	October	Nov	Dec
1	1,5	-0,5	4,2	6,3	10,7	15,2	16,8	16,2	13,1	9,2	3,8	2,0
2	1,4	-0,6	4,0	5,9	10,3	14,7	16,3	15,8	12,7	8,9	3,7	1,9
3	1,4	-0,7	3,8	5,4	10,0	14,3	15,9	15,3	12,4	8,7	3,6	1,9
4	1,1	-1,0	3,7	5,0	9,8	13,7	15,5	15,0	12,2	8,5	3,5	2,1
5	1,2	-1,1	3,5	4,7	9,5	13,7	15,1	14,7	12,0	8,2	3,2	2,1
6	1,1	-1,1	3,3	4,7	10,1	14,4	15,4	14,6	12,1	7,9	3,1	2,1
7	1,1	-1,2	3,1	5,2	11,5	15,3	16,3	15,3	12,2	7,9	3,0	2,0
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9	1,3	-0,7	4,0	7,8	14,0	17,2	18,2	17,6	14,2	9,0	3,2	2,1
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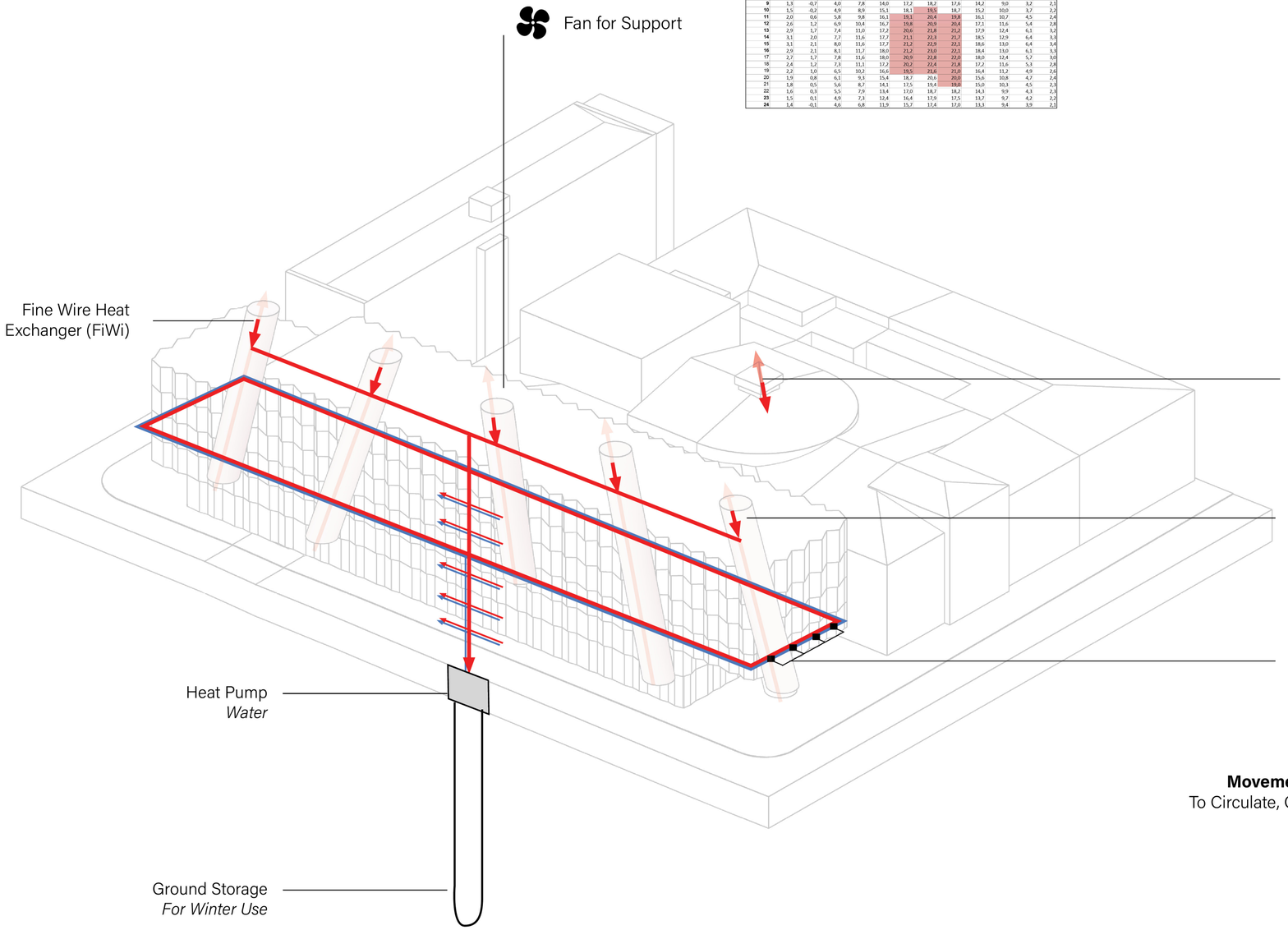
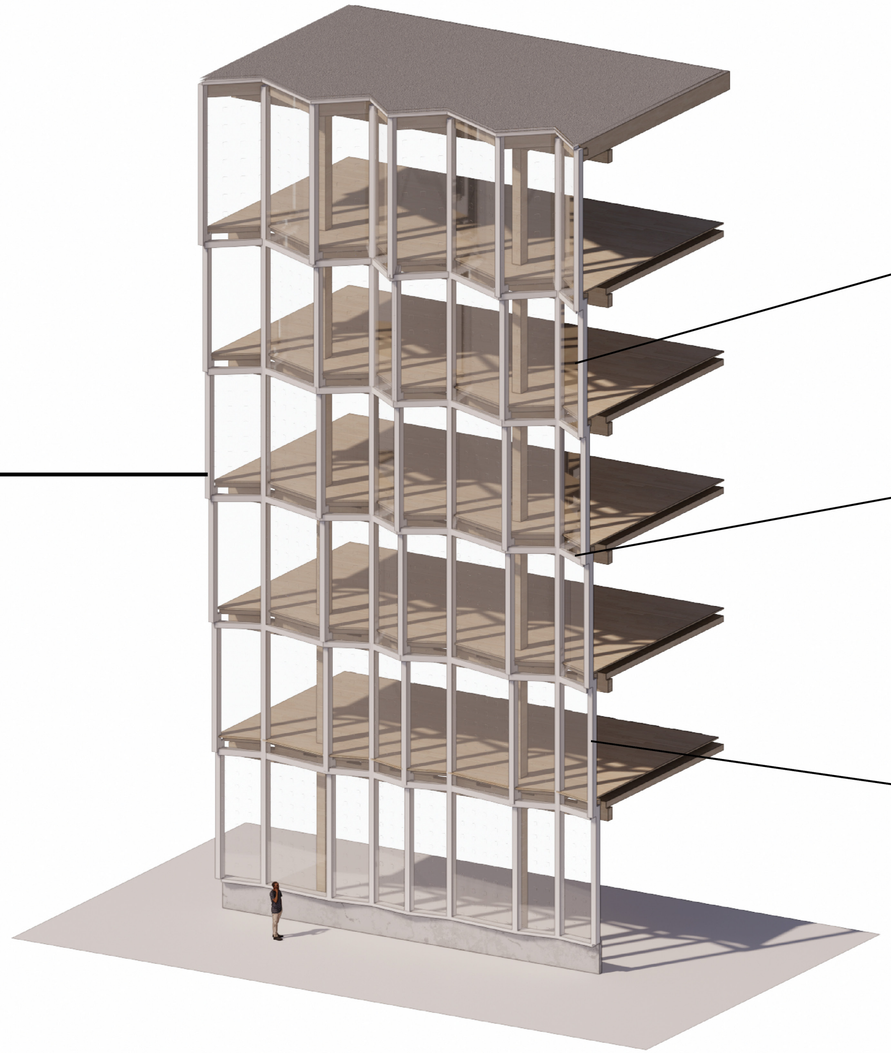


CLIMATE DESIGN
Komische Oper Berlin

Movement of Air and Water
To Circulate, Cool and Heat the Air

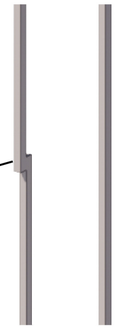


WOOD

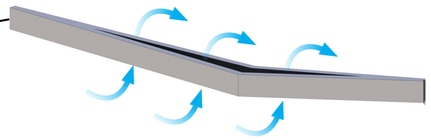


FACADE CONSTRUCTION
Wooden Frames

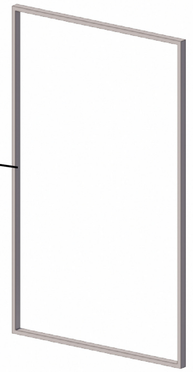
3 ELEMENTS



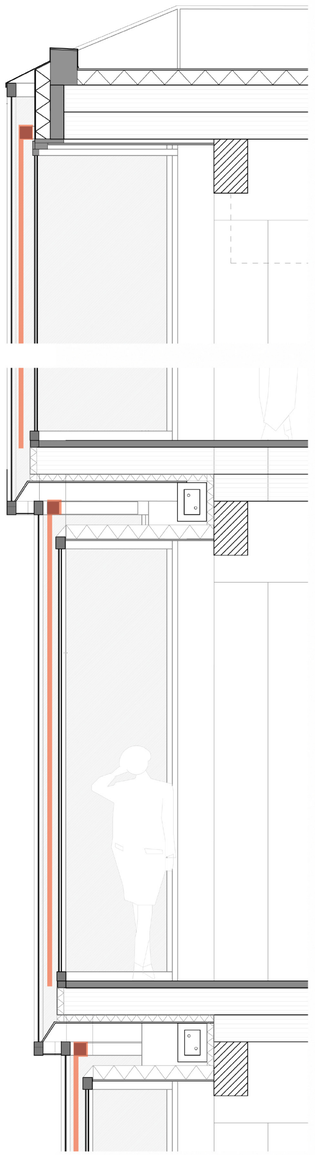
VERTICAL MULLIONS

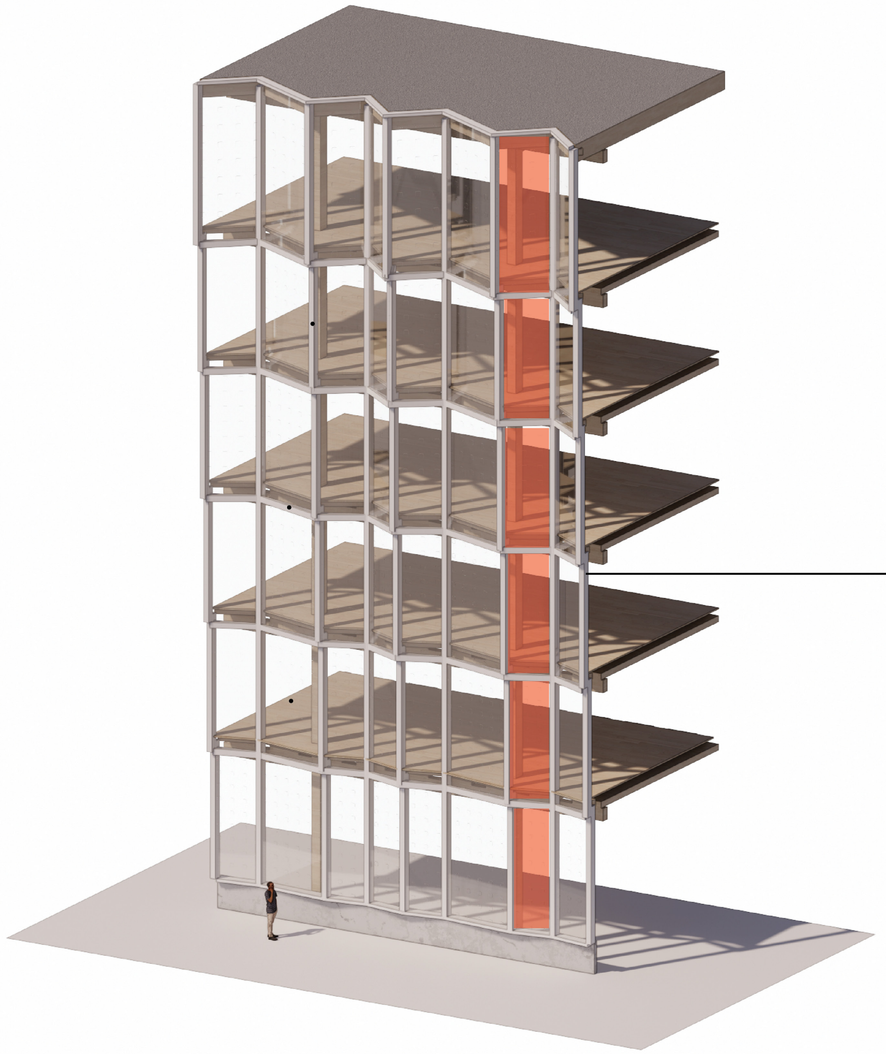


HORIZONTAL TRIANGLE LOUVERS

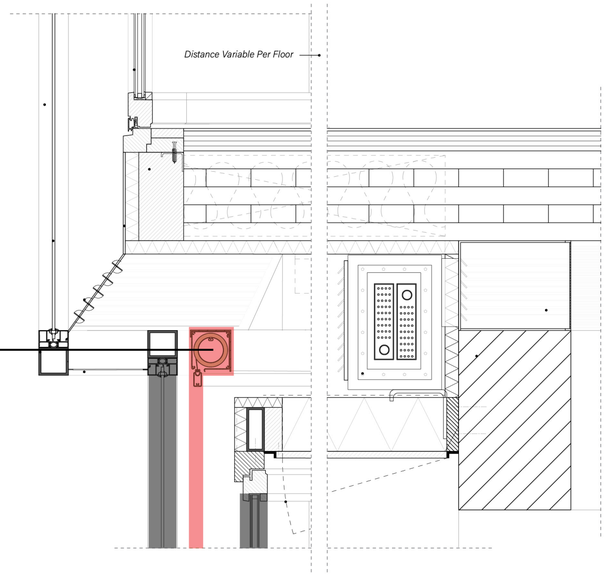


CLICK GLASSFRAME

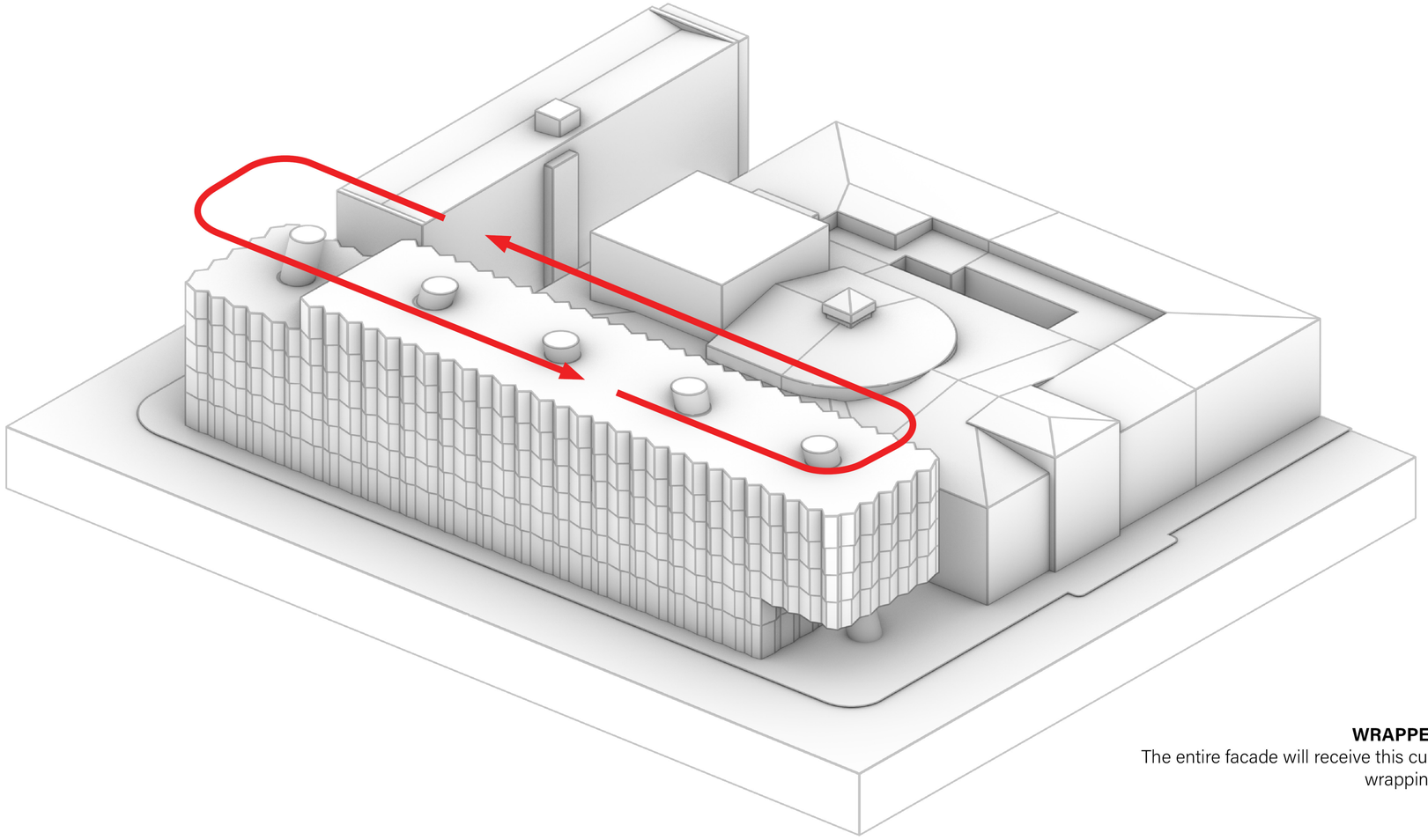




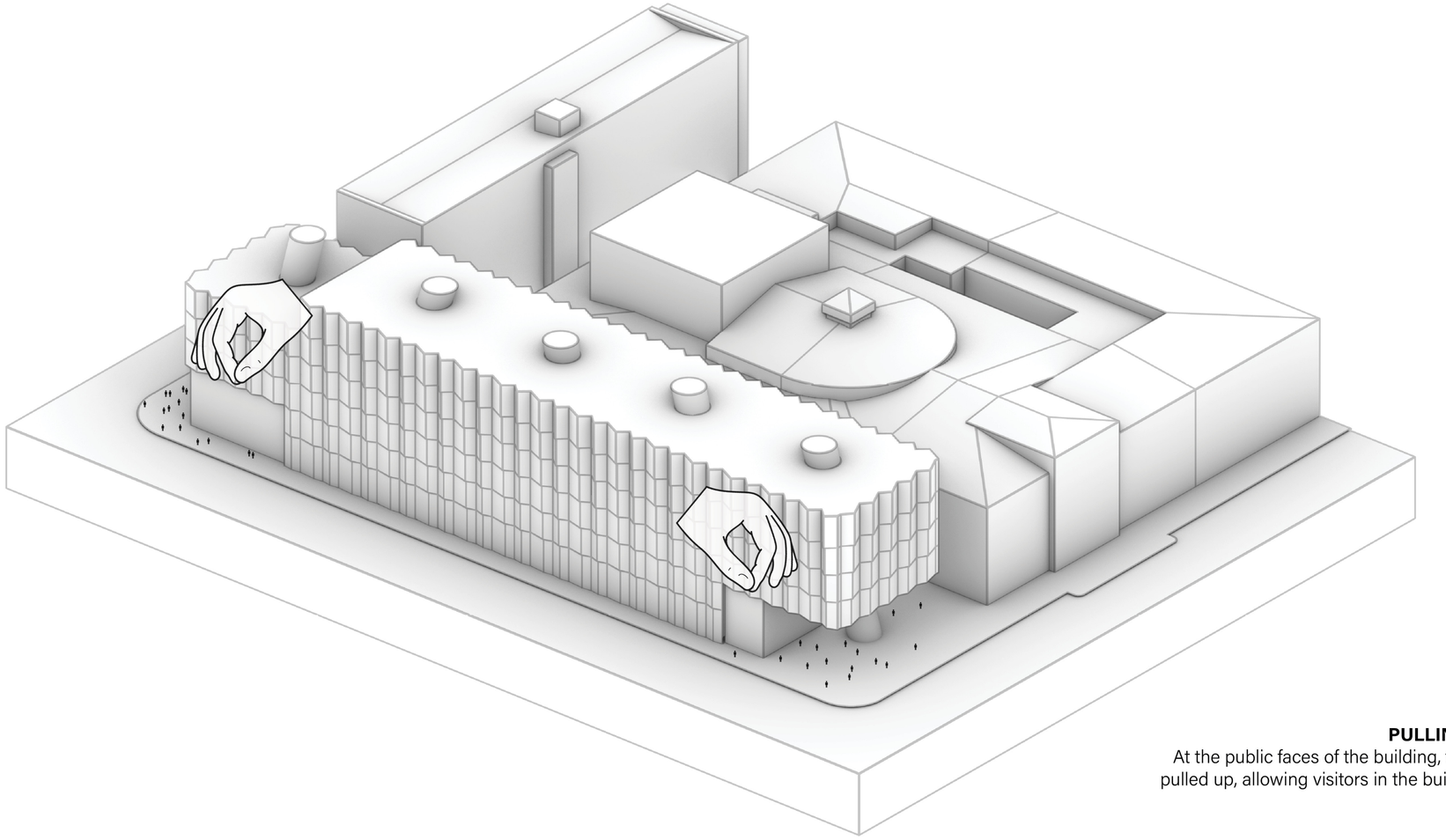
SOLAR SHADING



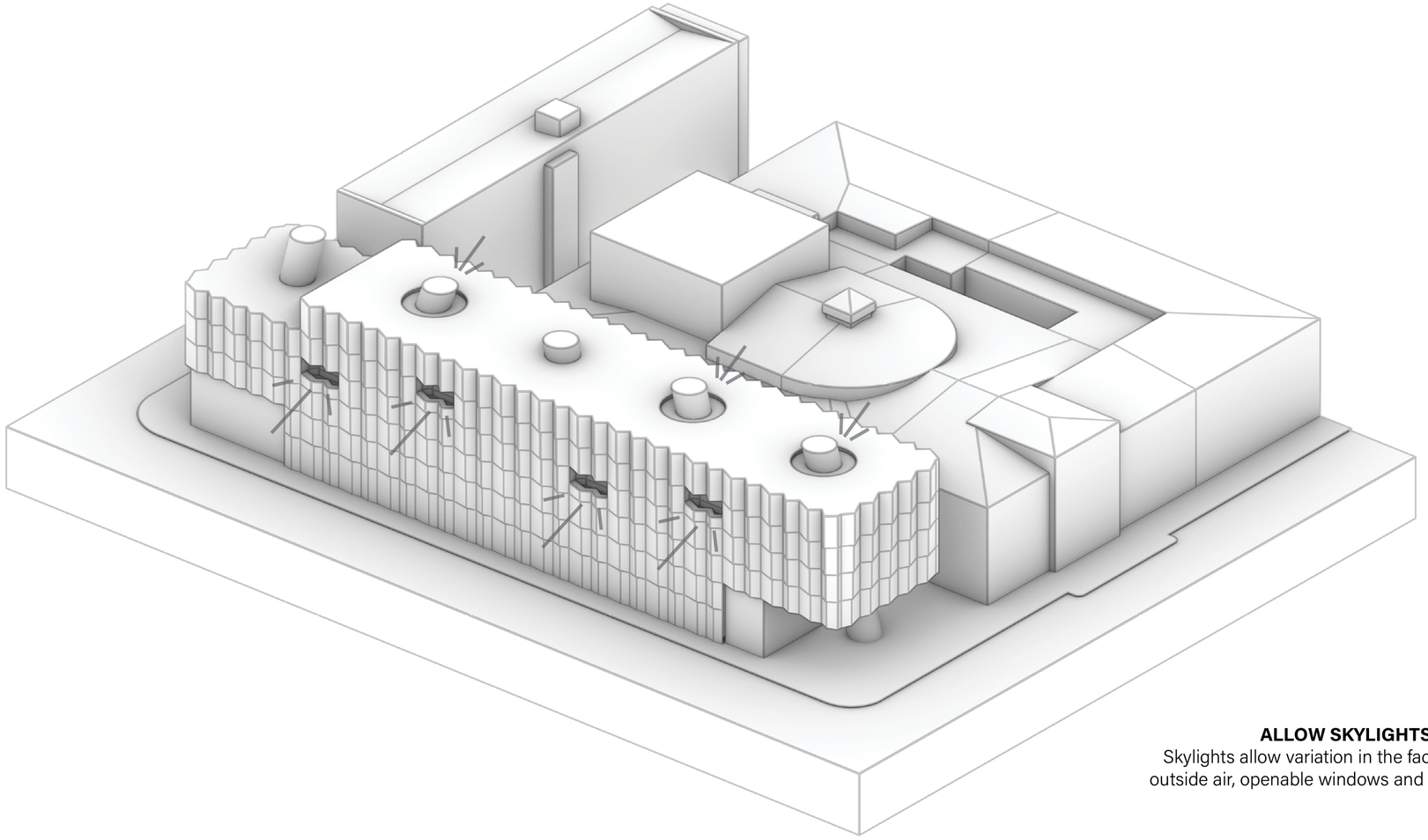
SOLAR SHADING
In Between Cavity



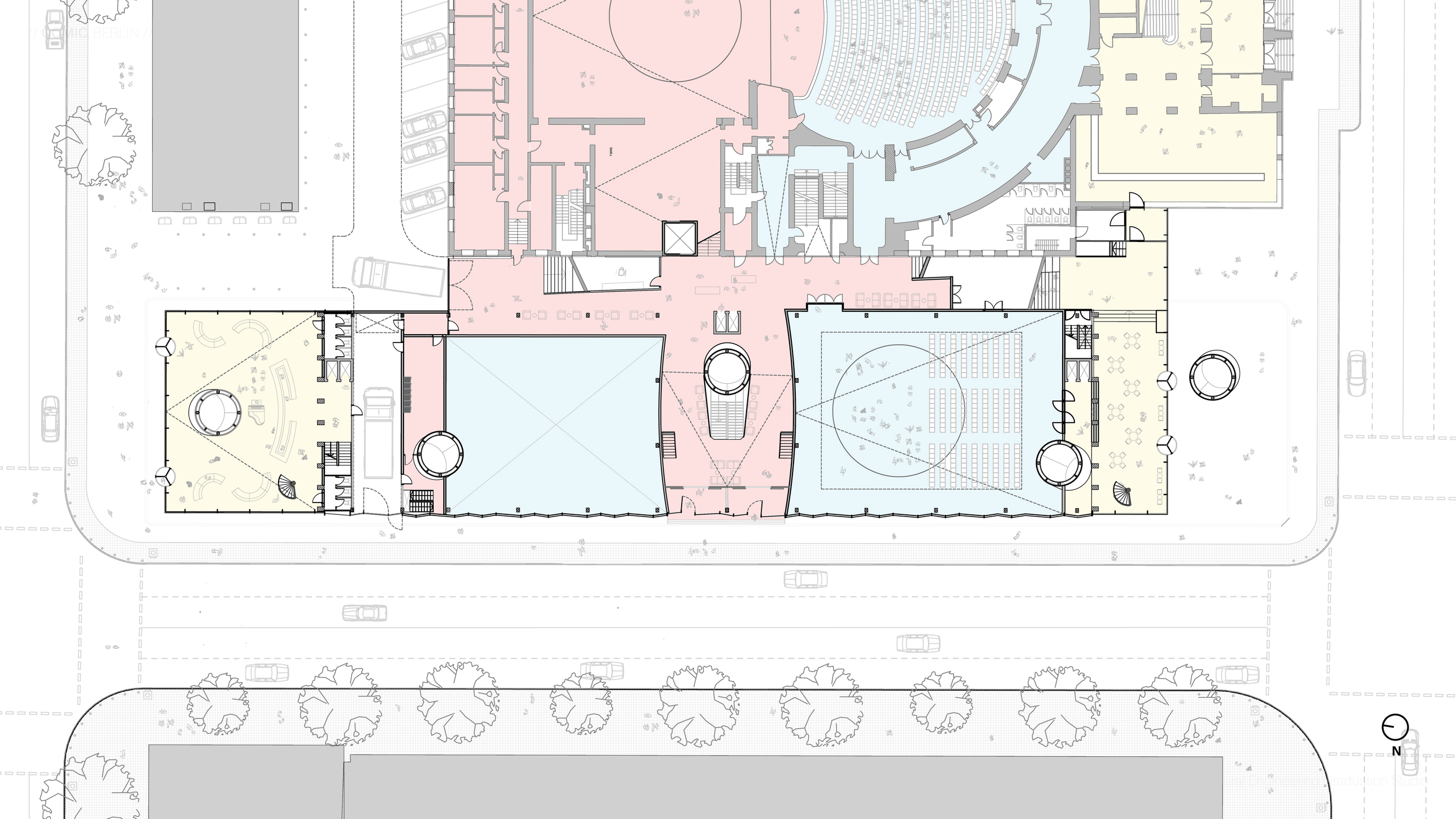
WRAPPED GLASS FACADE
The entire facade will receive this curtain climate facade, wrapping the entire building



PULLING-UP CURTAIN
At the public faces of the building, the curtain will be pulled up, allowing visitors in the building, litteraly and methaphorically



ALLOW SKYLIGHTS AND BALCONIES
Skylights allow variation in the facade, connection the outside air, openable windows and more natural light in the upper floor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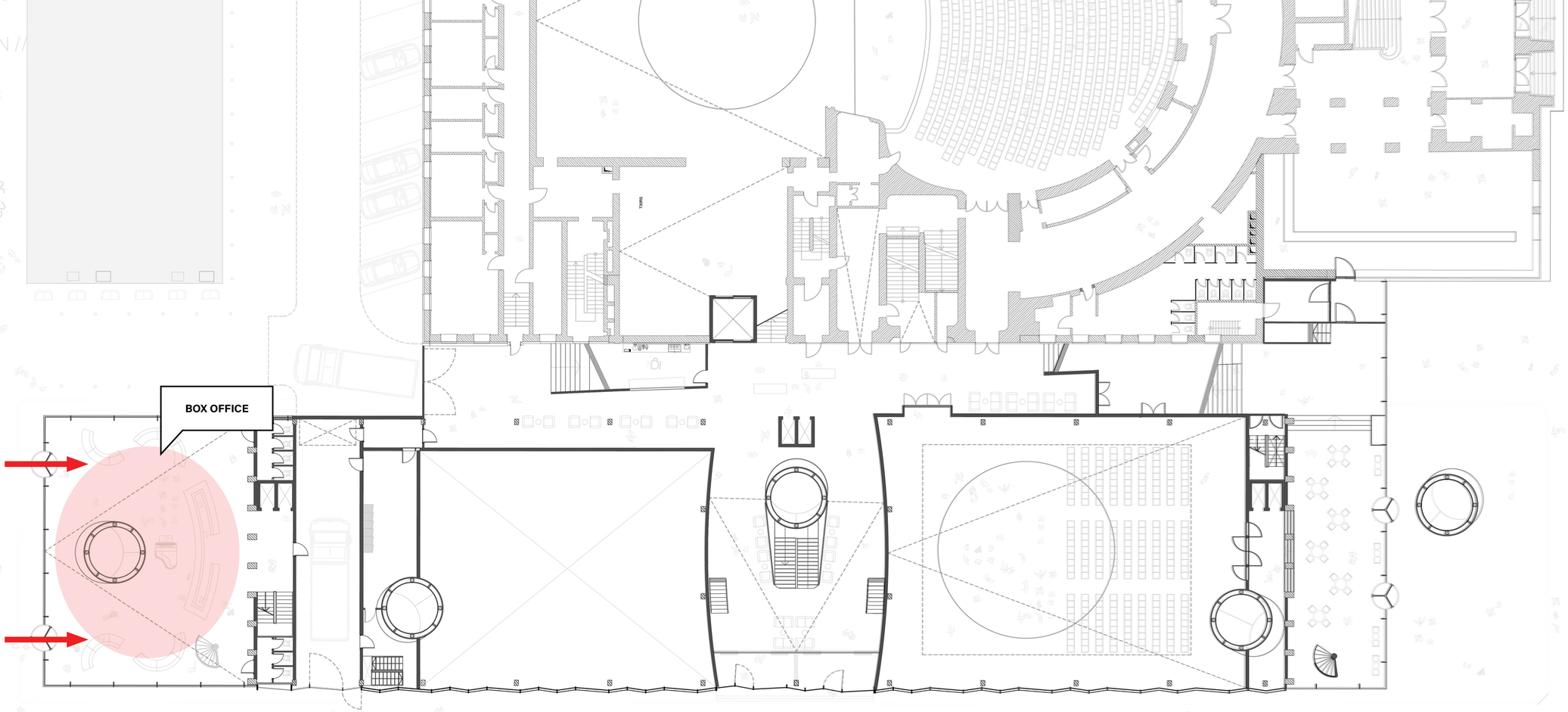
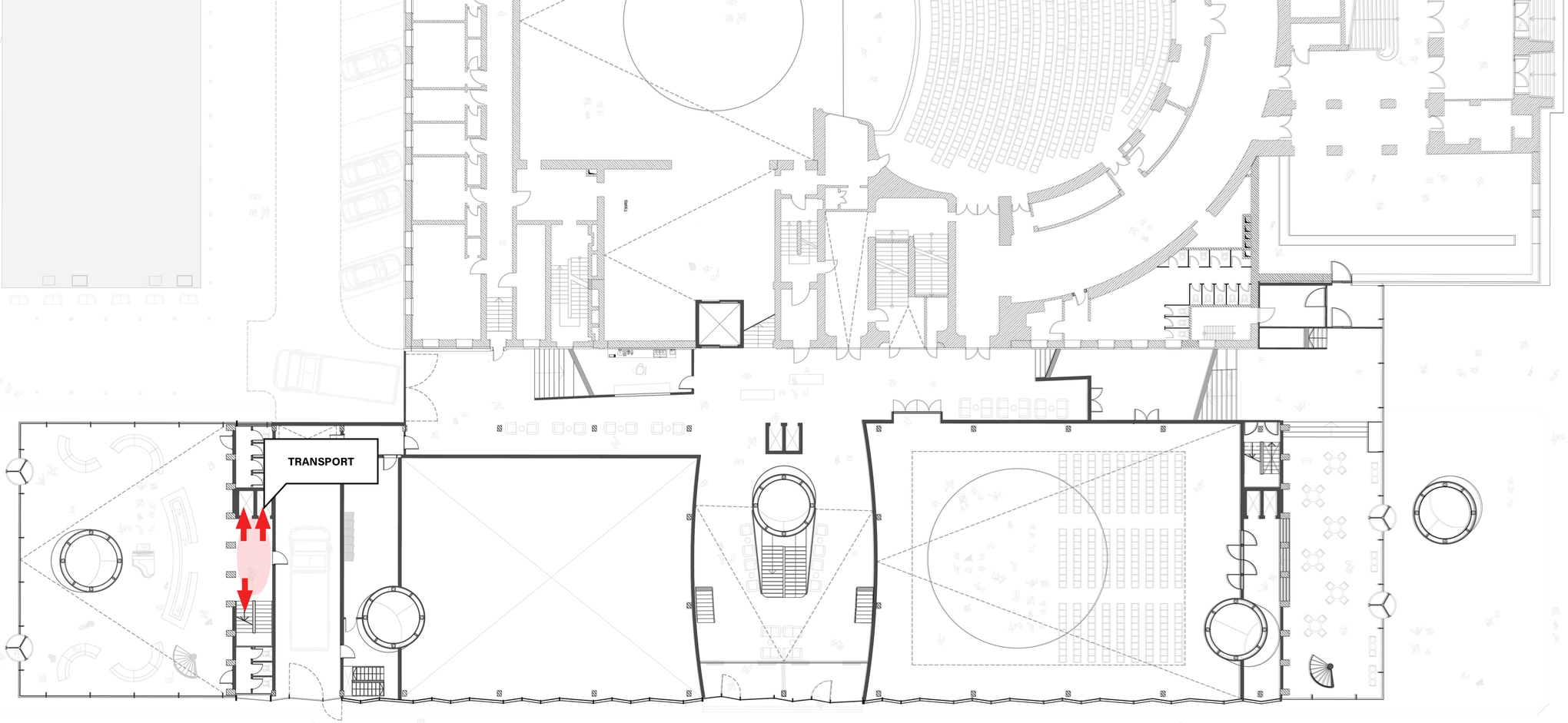


GROUNDFLOOR

Public Plinth

N

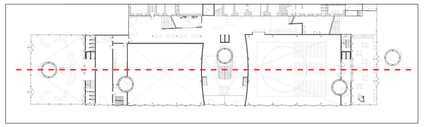




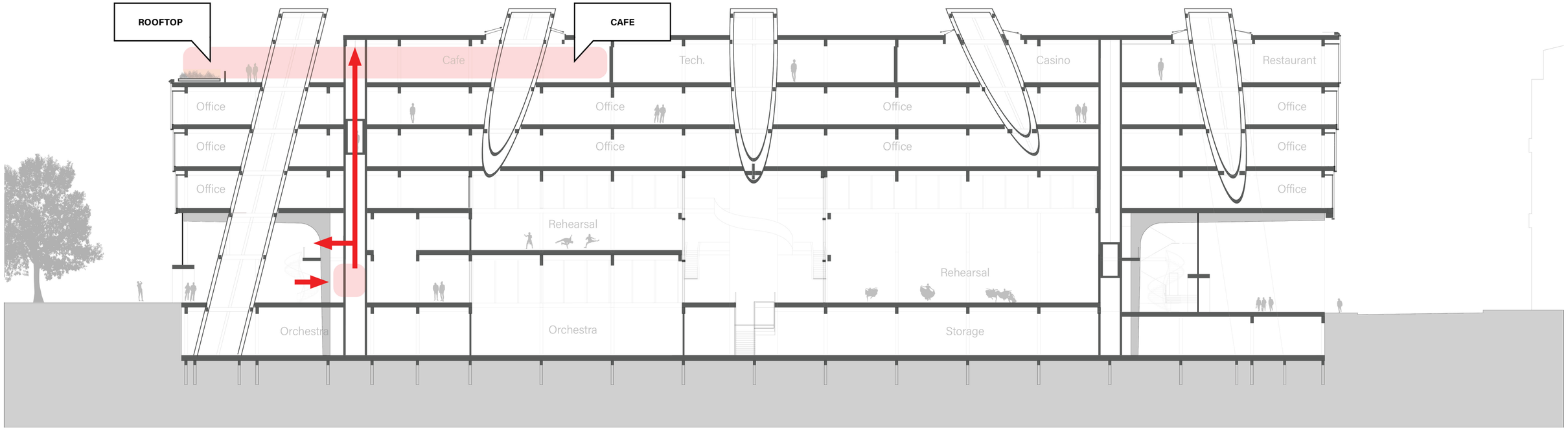
GROUNDFLOOR

Public Plinth

N

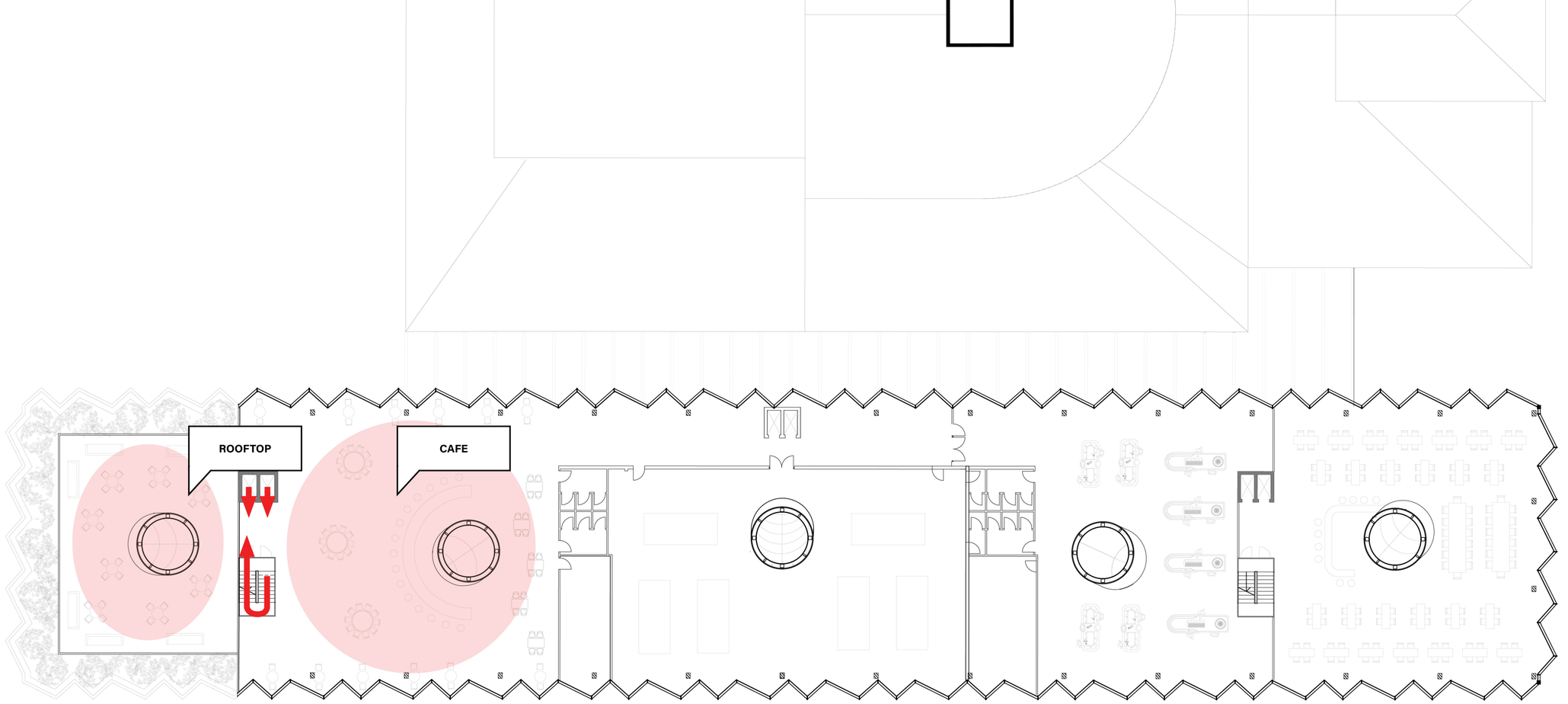


Section AA



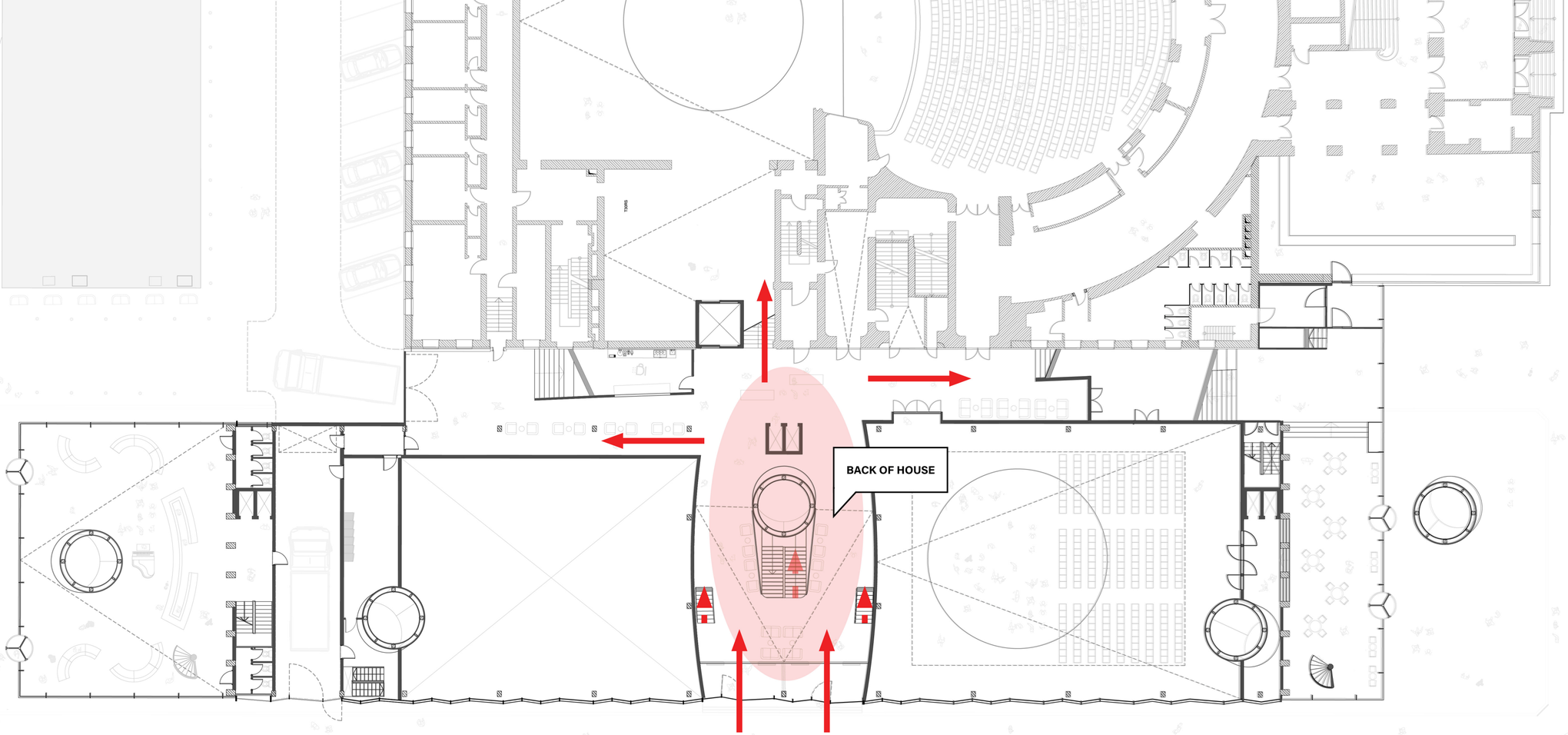
SECTION AA

Komische Oper Berlin



5TH FLOOR

Public Cafe, Restaurant, Casino

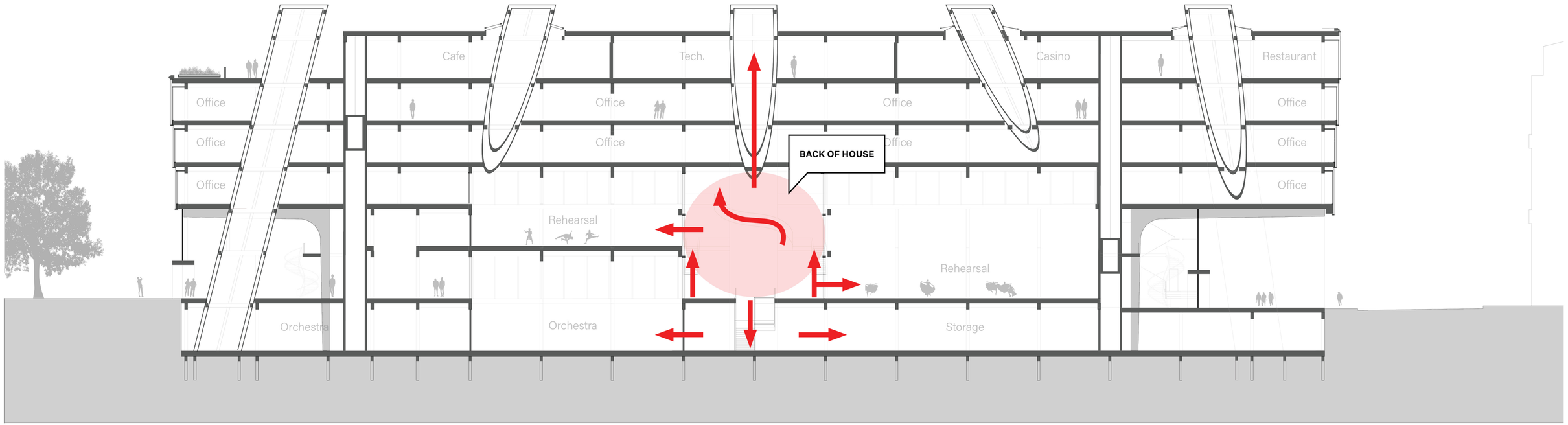




Employee / Performer

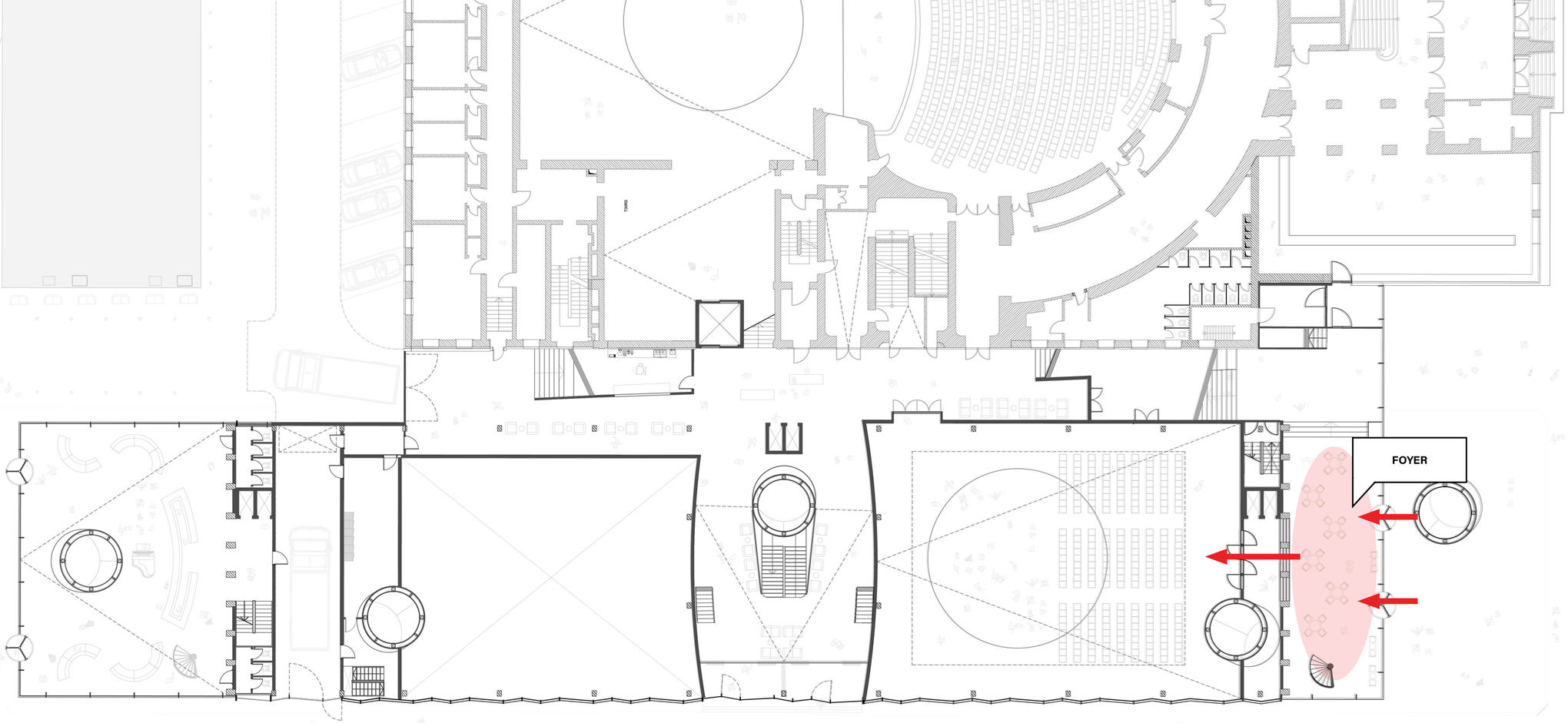
GROUNDFLOOR

Back of House Entry



GROUNDFLOOR

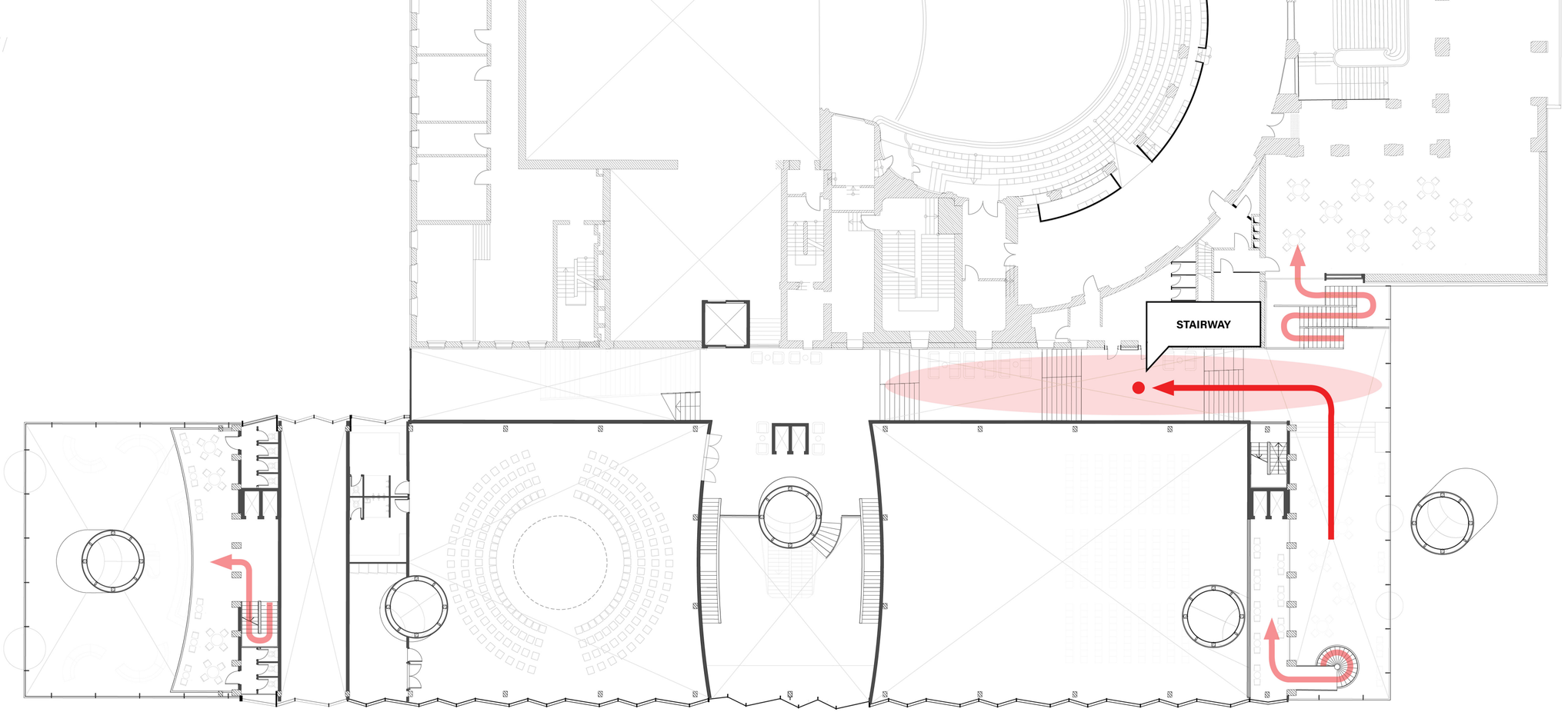
Back of House Entry



GROUND FLOOR

Foyer





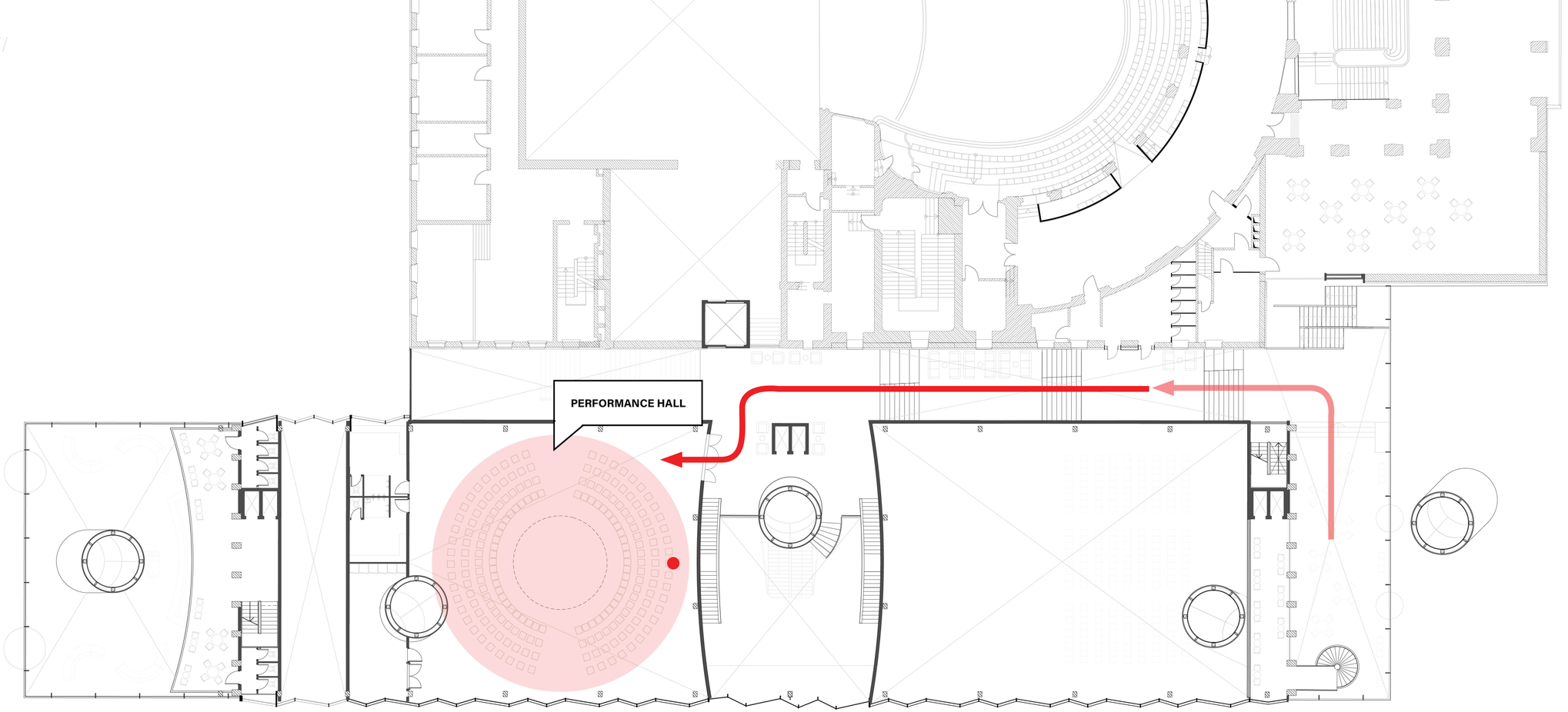
FIRST FLOOR

In Between Space



IN BETWEEN SPACE

Existing and Extention Building



FIRST FLOOR

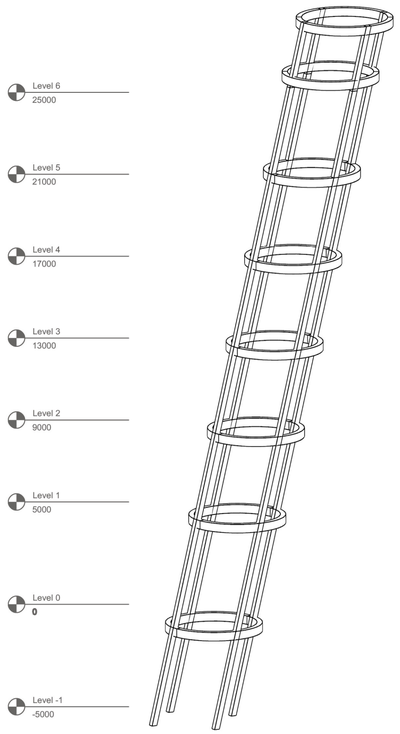
Performance Hall

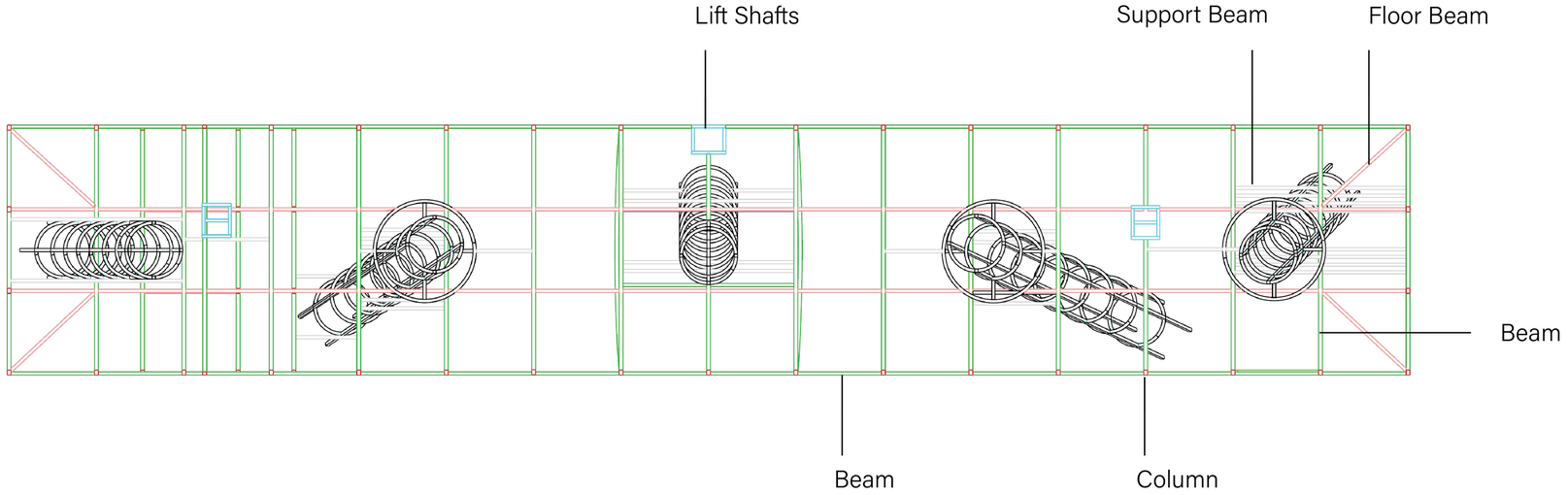


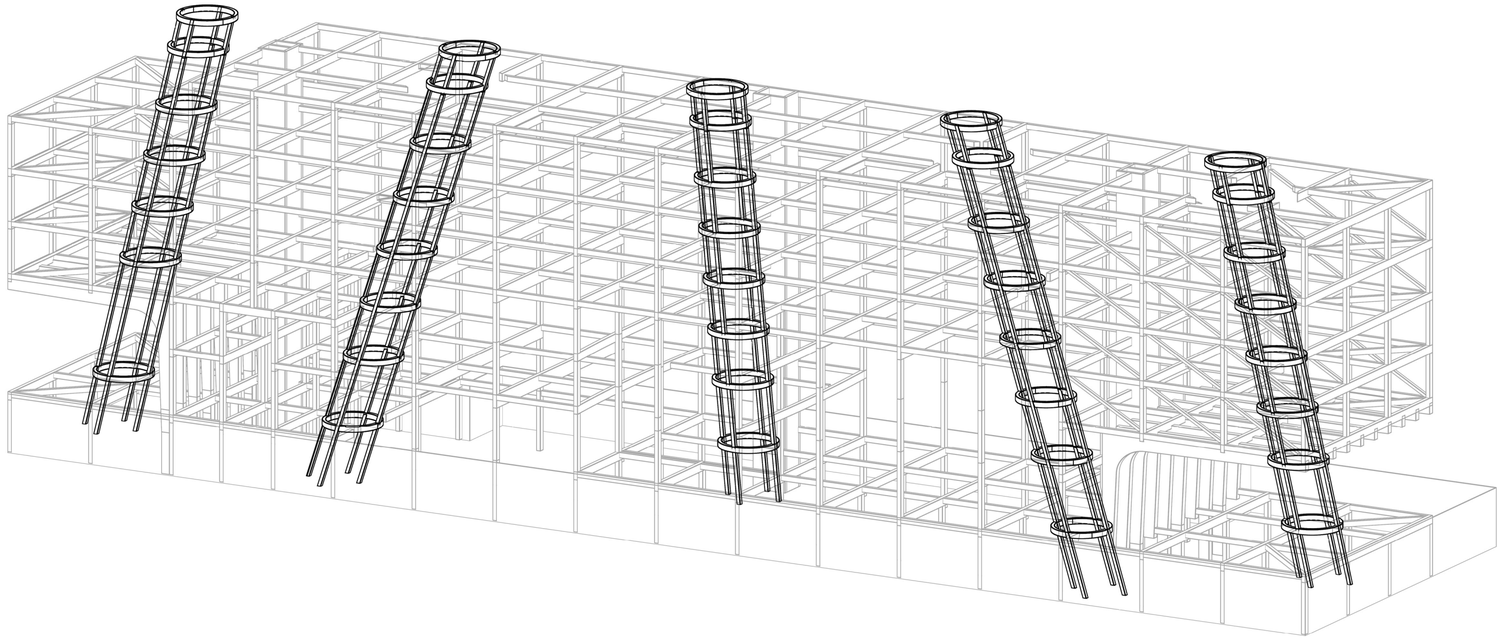
FIRST FLOOR
Performance Hall



FIRST FLOOR
Performance Hall

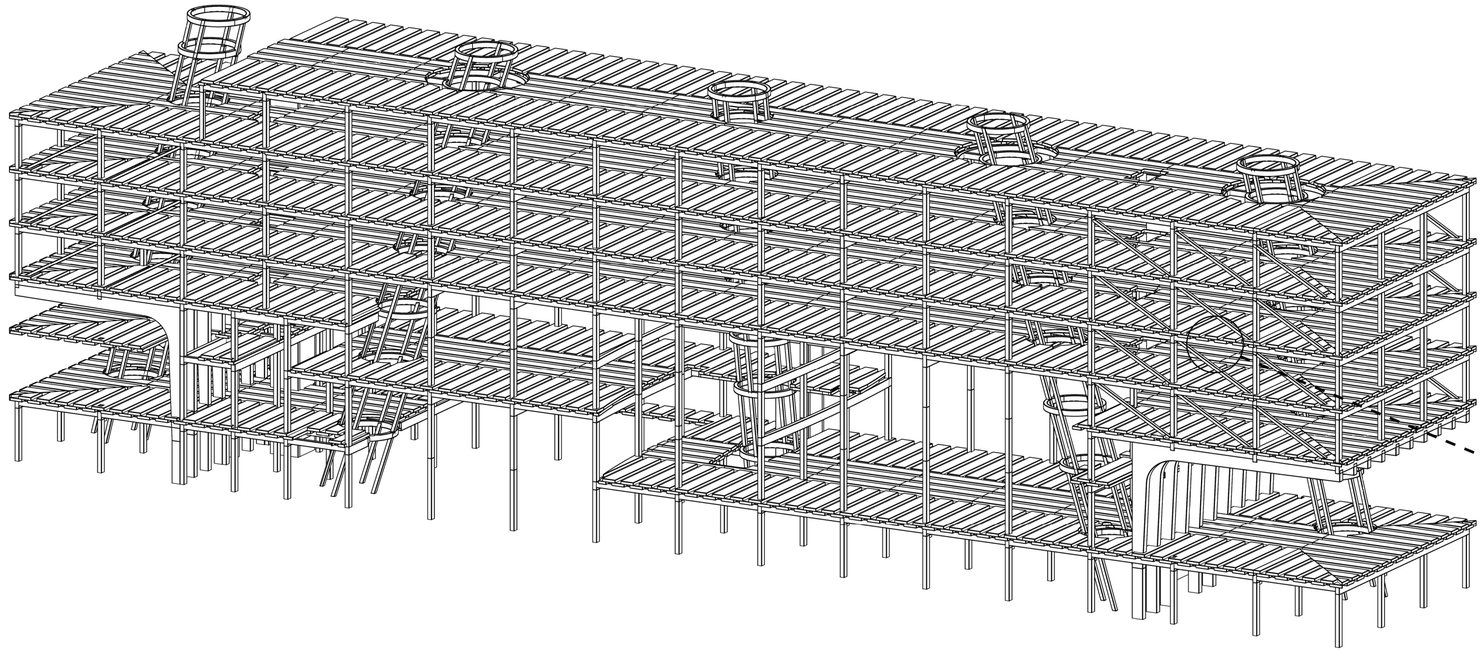


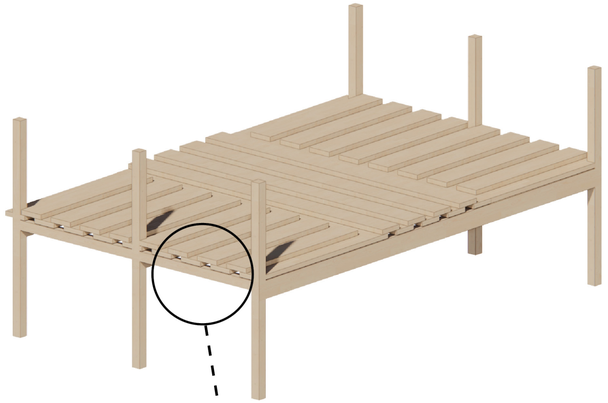


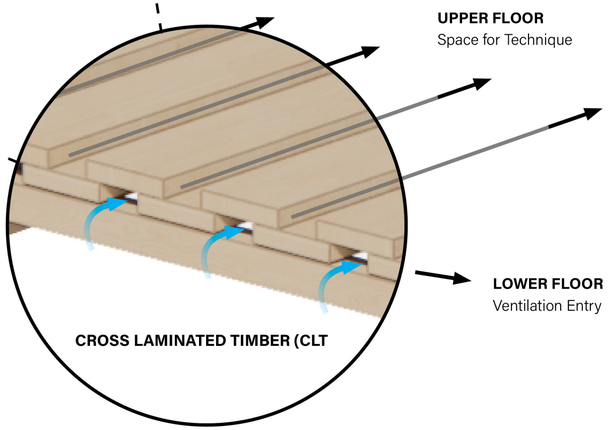


CONSTRUCTION

Wood

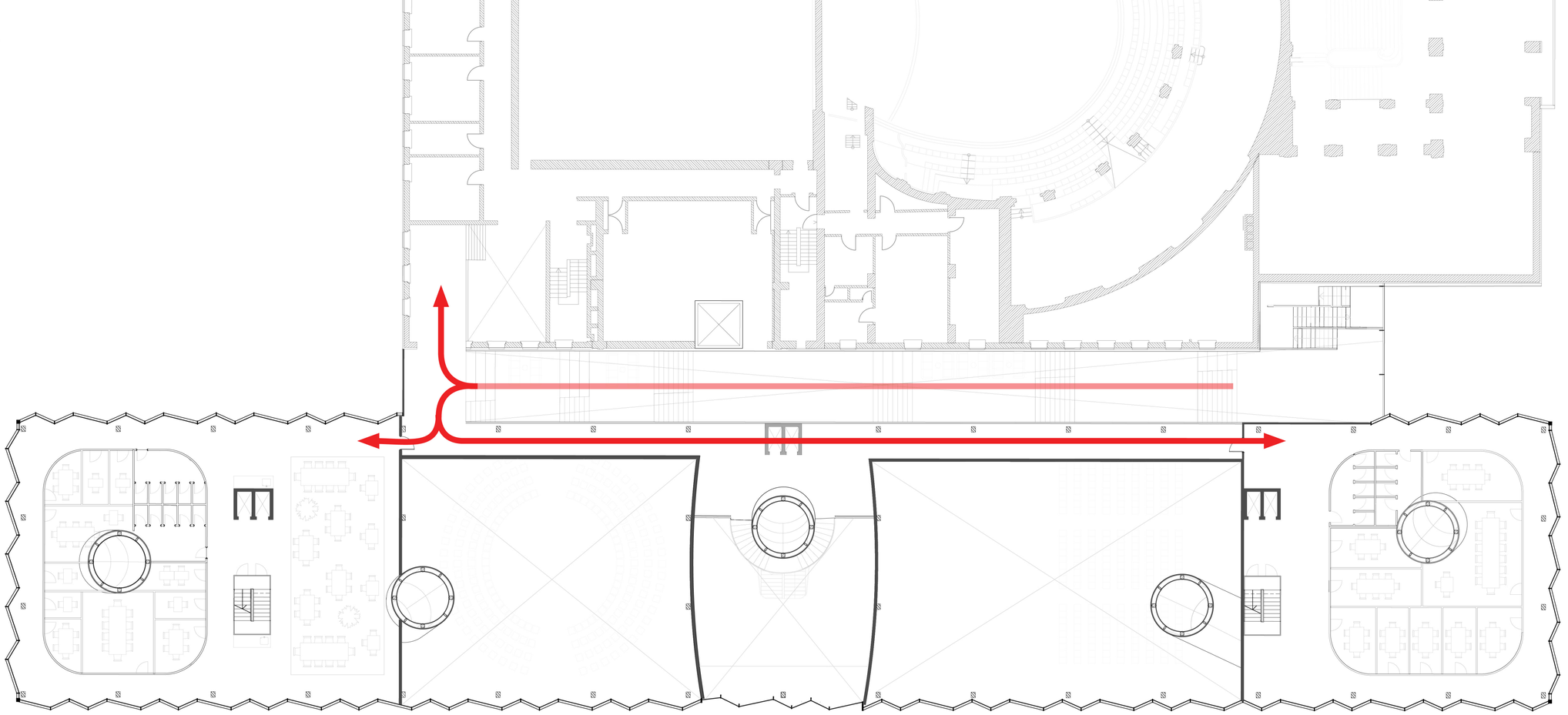






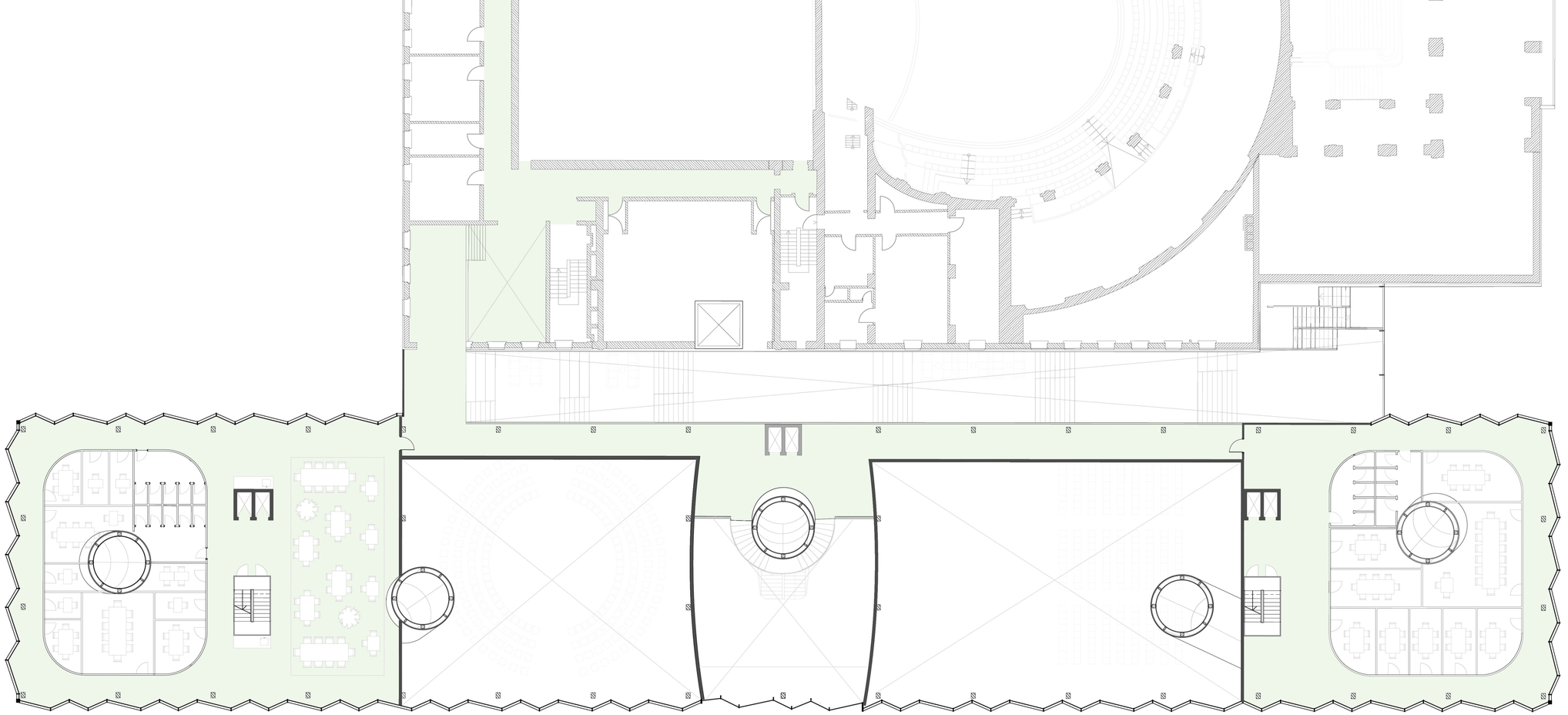
FLOORING - AIR

Crosslaminated Timber, Cross Laid



SECOND FLOOR

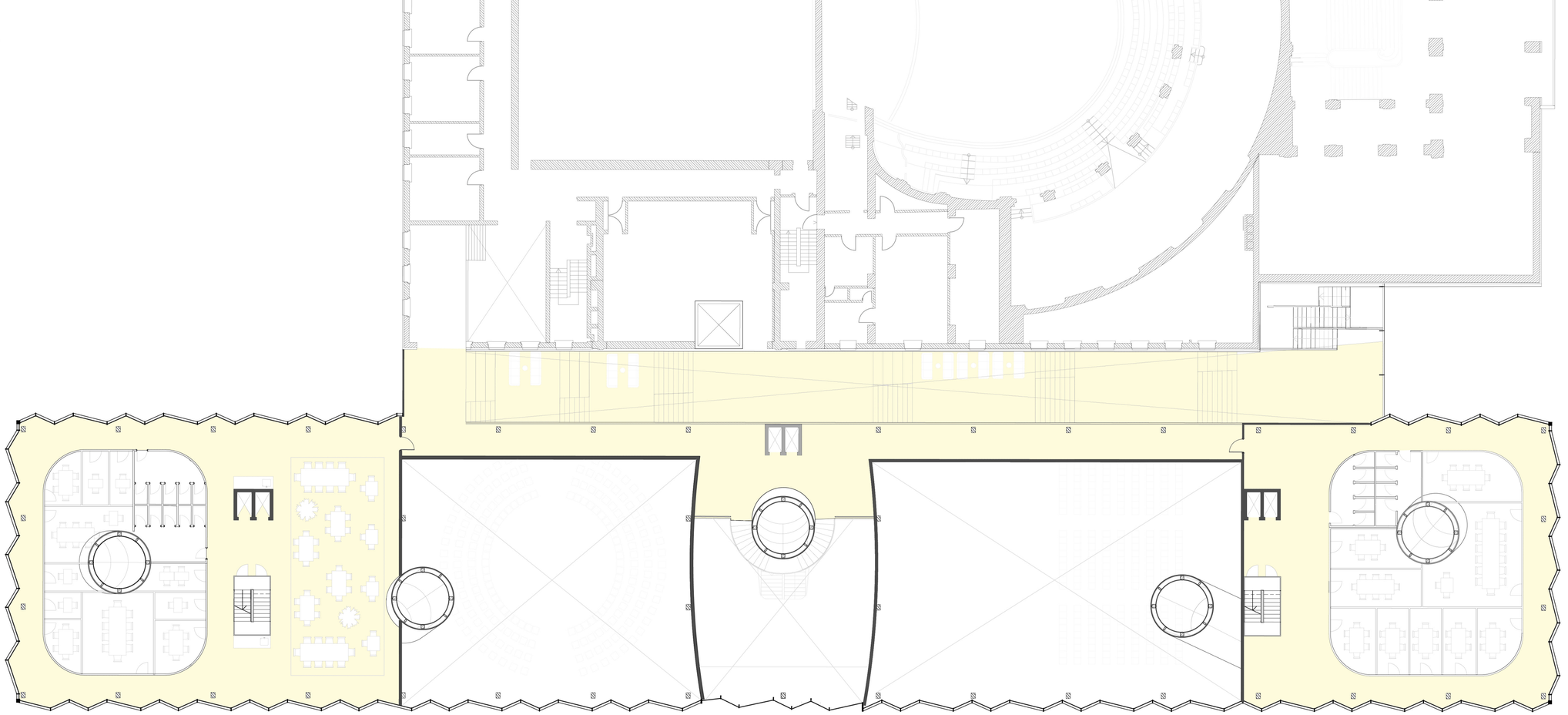
Public Offices Spaces



PRIVATE



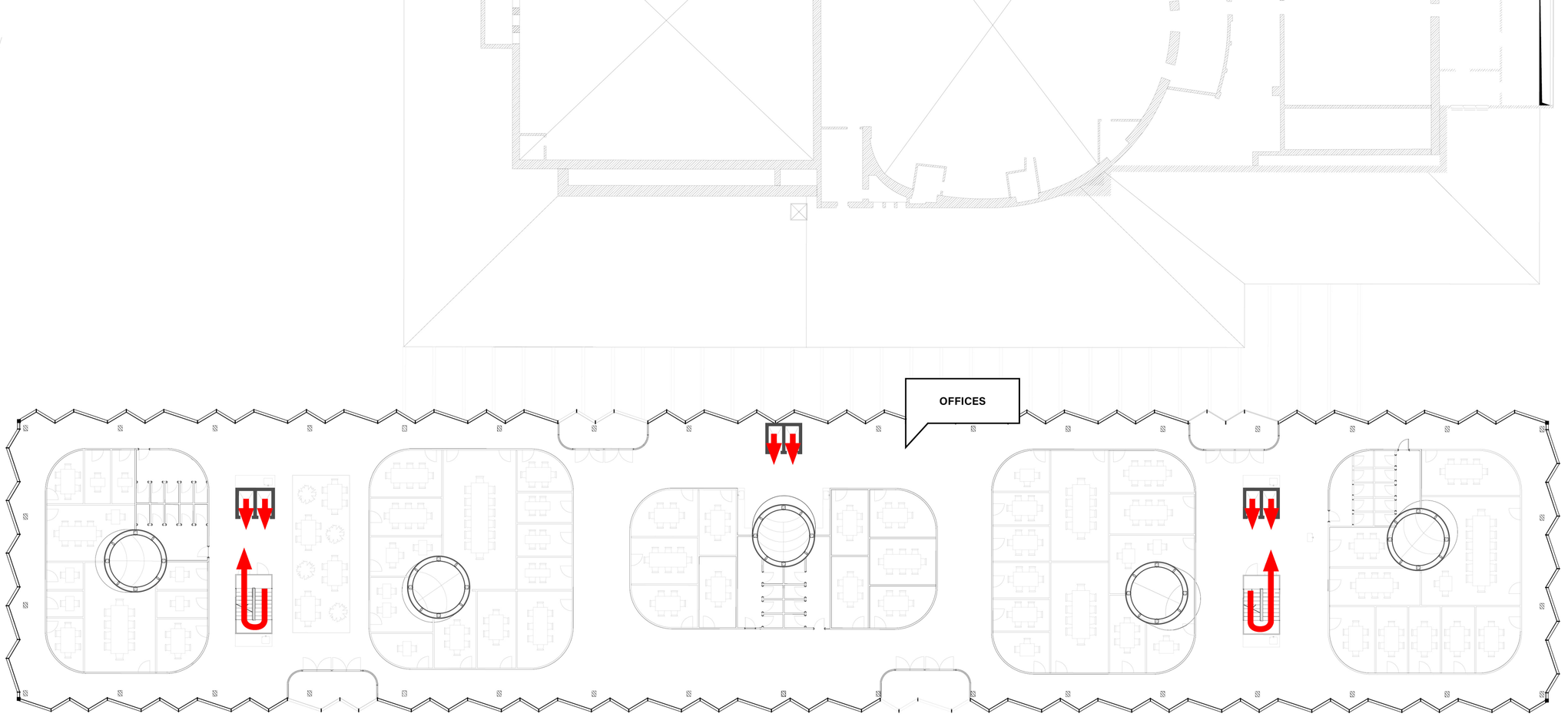
EMPLOYEE / PERFORMER



PUBLIC

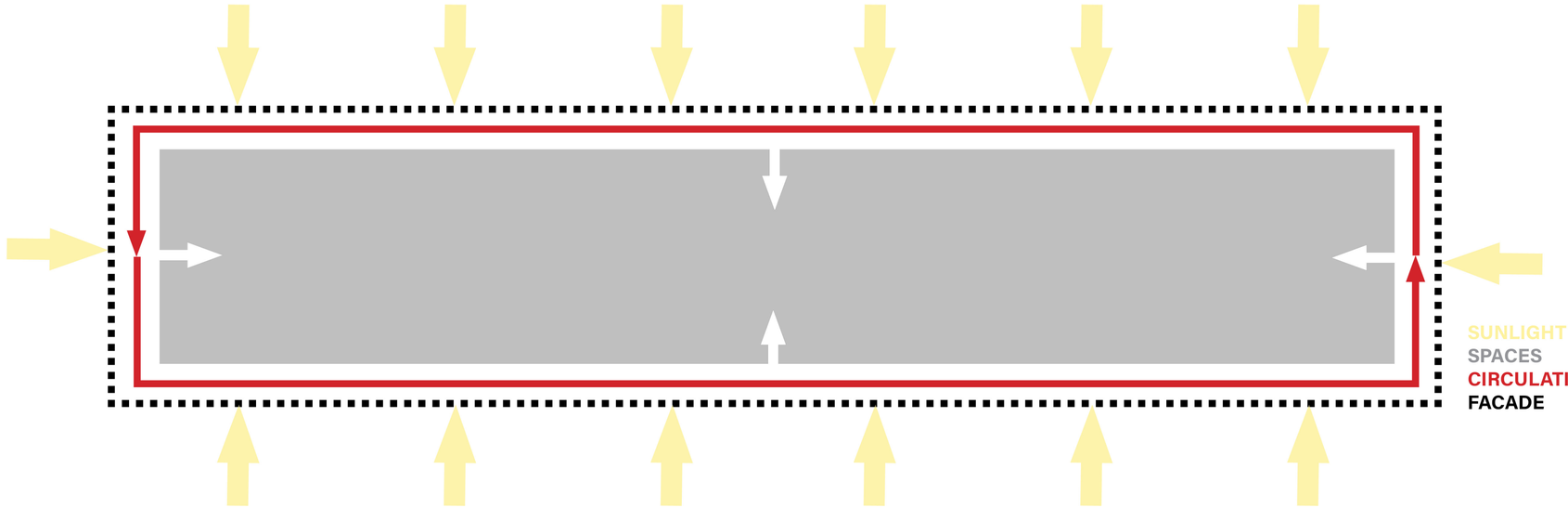


PEOPLE OF BERLN



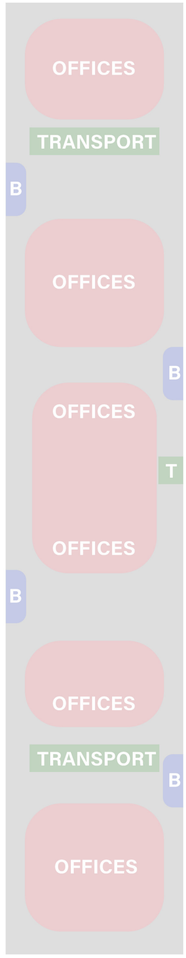
THIRD FLOOR

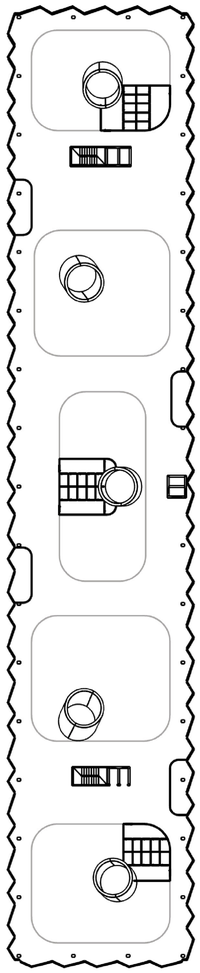
Offices Spaces



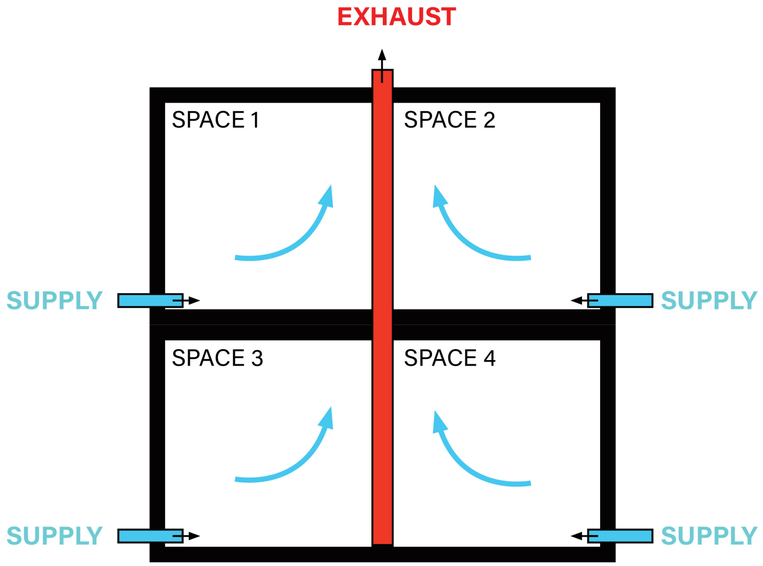
OFFSET FROM FACADE
To allow natural ventilation of the entire building as well as a lively facade with the transport of people



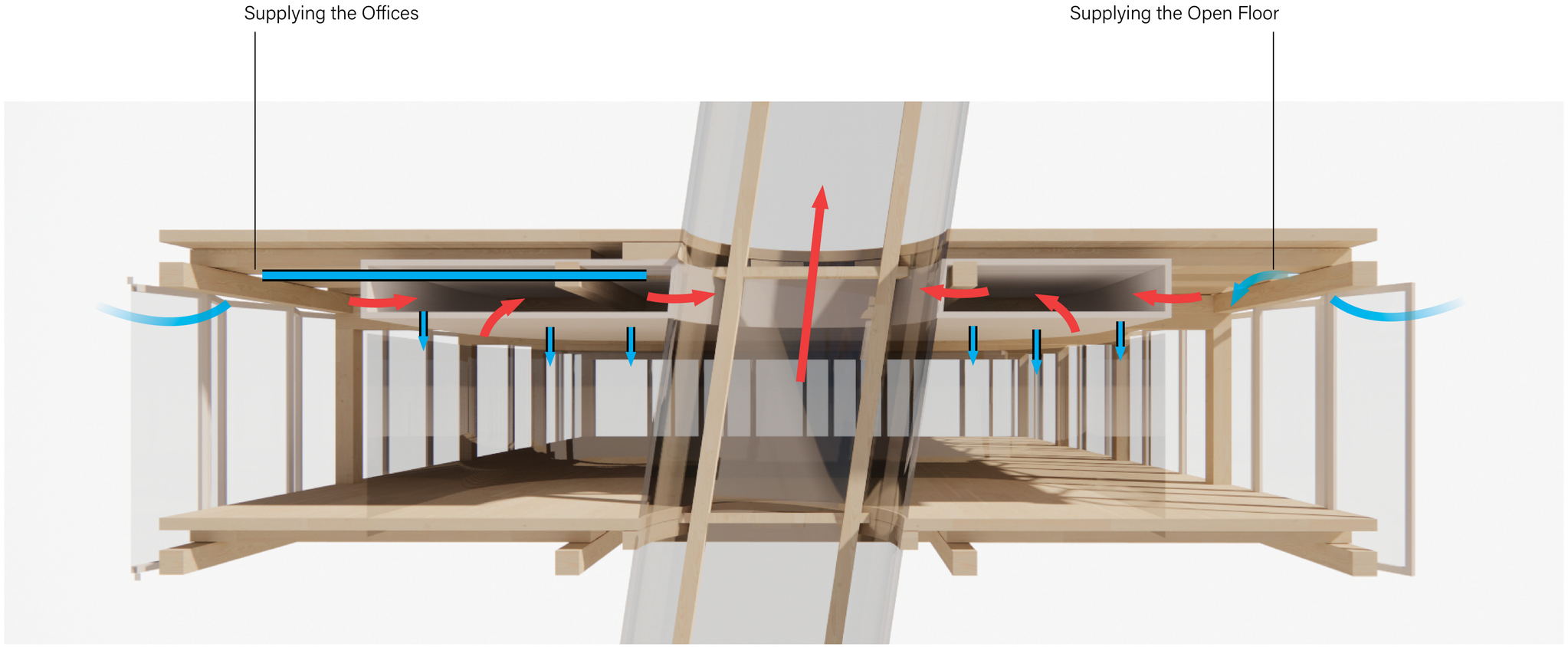




OFFICE FLOOR DIAGRAM
Open floorplate with offices surrounding the exhaust of air.



MULTIPLE SPACES
One central shaft and direct entry of air

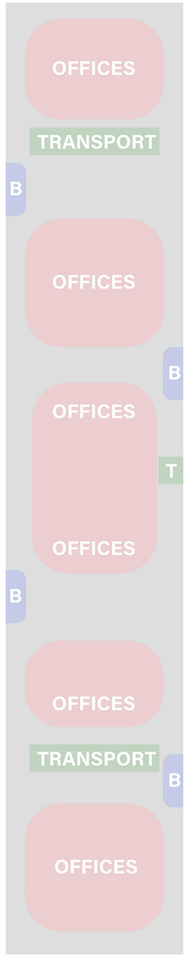


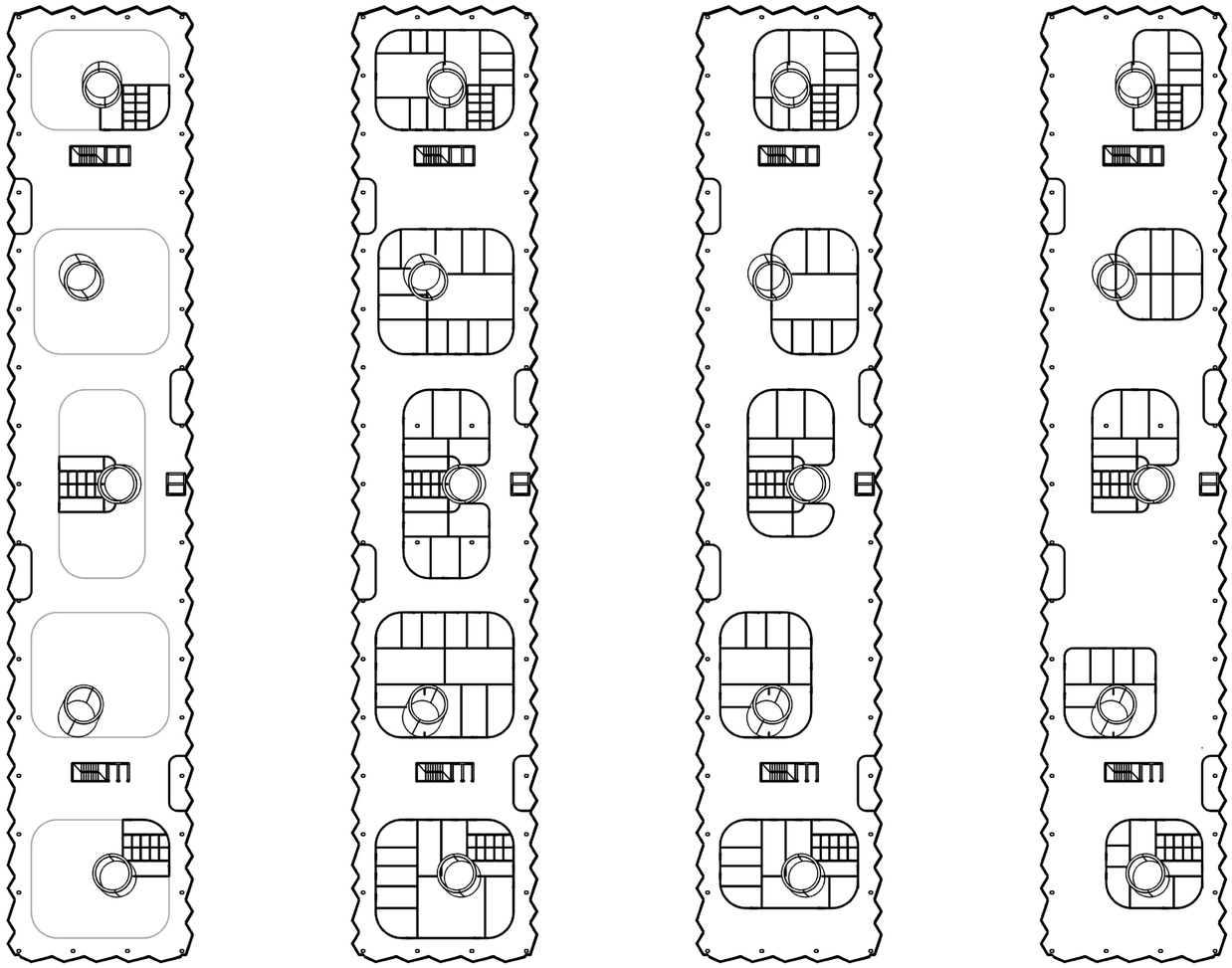
Movement of Air through Office Space

Tubes
Entry Air
Exhaust Air

Ventilation Strategy

Off the Lowered Ceiling





OFFICE FLOOR DIAGRAM
Open floorplate with offices surrounding the exhaust of air.

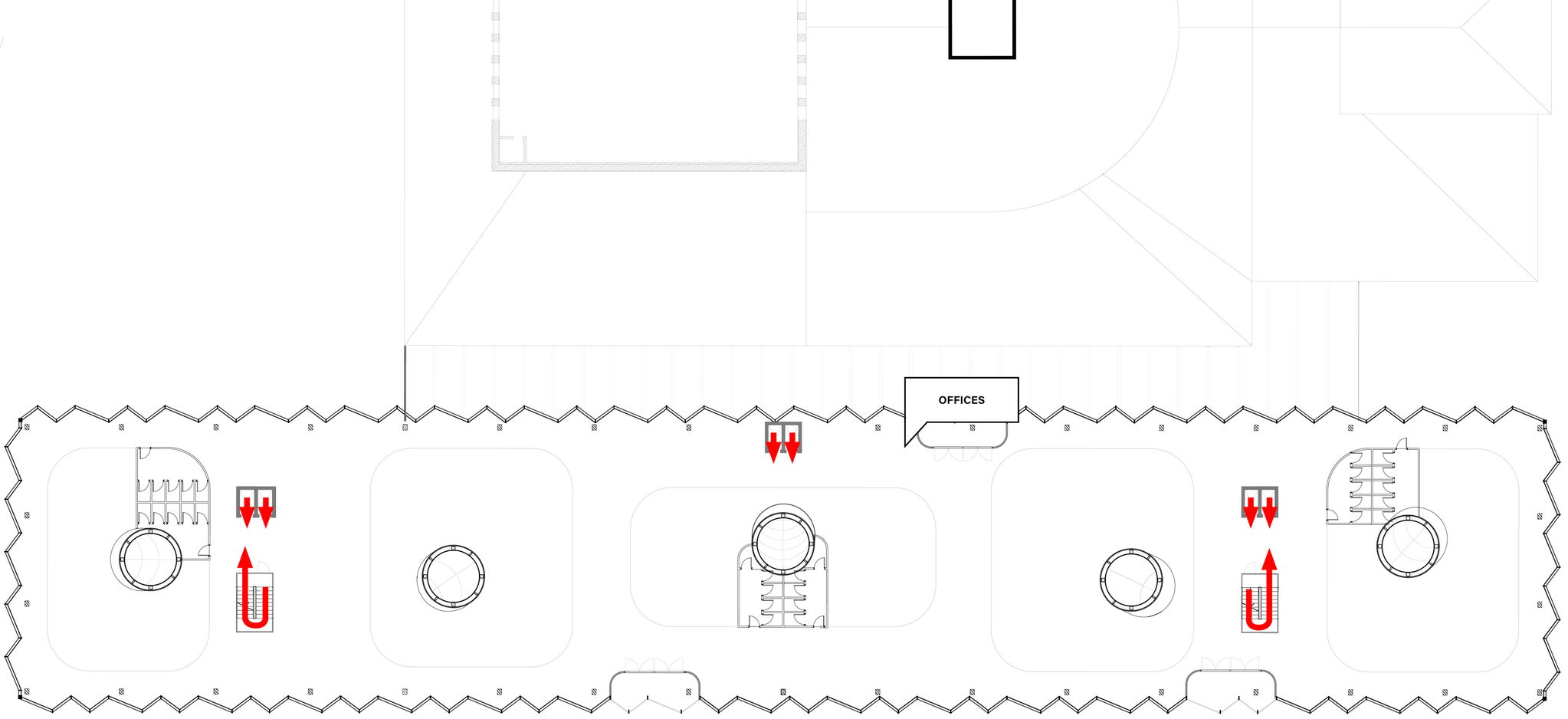
All Office Spaces
2028

Modification
2035

Modification
2040

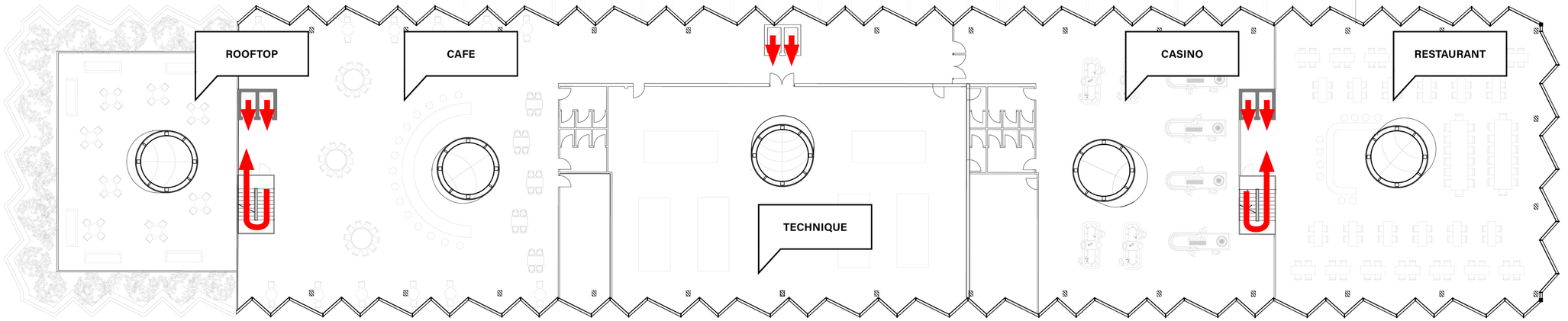

2028


2040



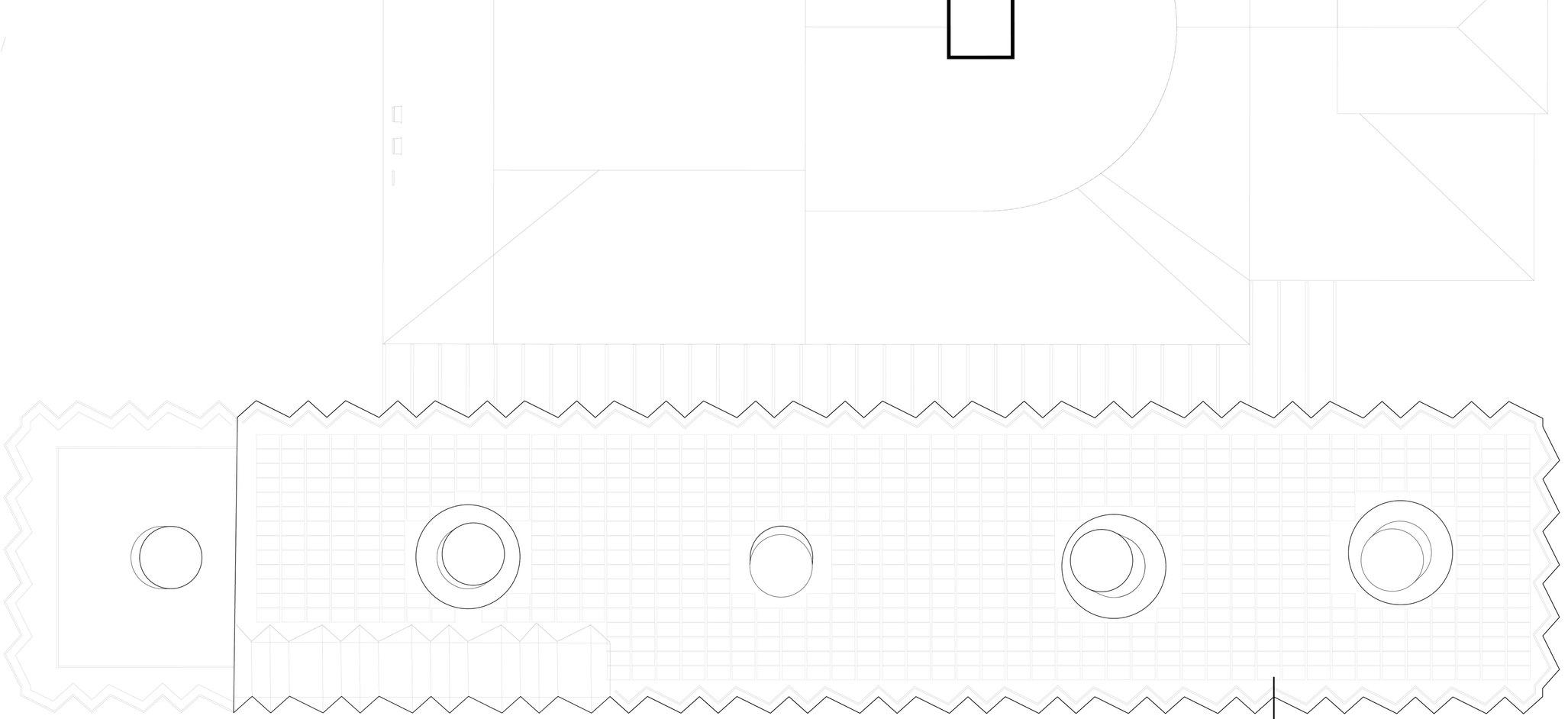
FOURTH FLOOR

Offices



5TH FLOOR

Public Cafe, Restaurant, Casino



ROOF

Solar Panels

CONCLUSION



Komische Oper Theatre Extention



‘COM\C’

/ ˈkom.ik / - [ko . mic]

Response to the Formal Opera



“OPÉRA TRAGIQUE”
(Genre, 1700, France)

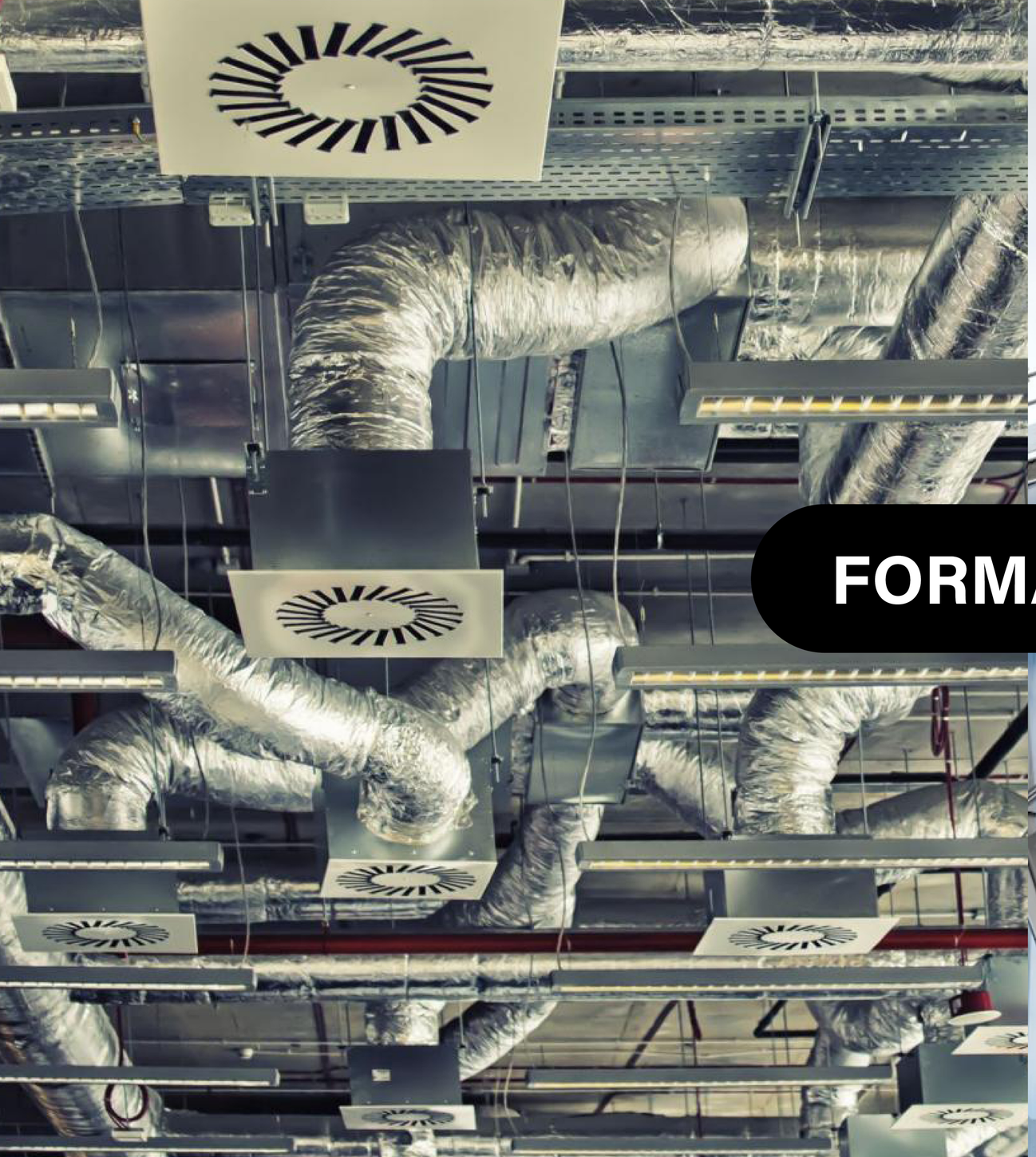
FORMAL

RESPONSE

“OPÉRA COMIQUE”
(Genre, 1700, France)

LESS FORMAL

FORMALITY

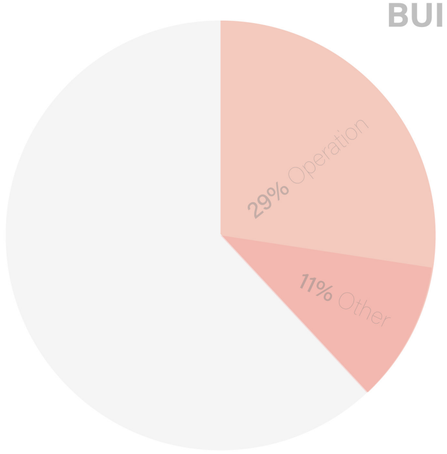




Mechanical Ventilation

Global Energy Consumption

Built Environment

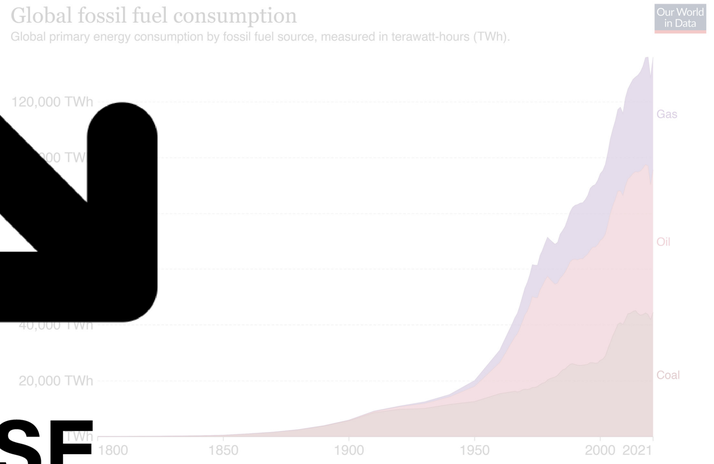


39%
BUILT E NMENT

61%
Other Industries

Global Fossil Fuel Consumption

All Industries

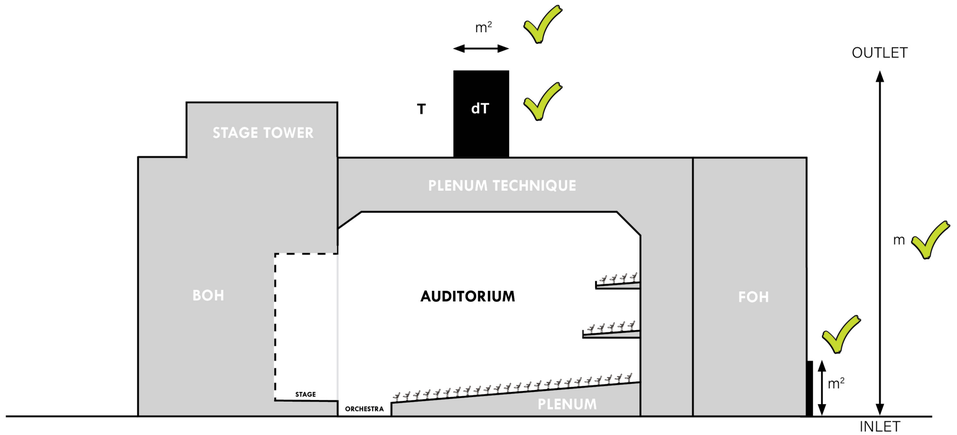


DECREASE

Sustainable development means using **vision, imagination and creativity to shape the future**, and having the **courage to try new things** and **explore unfamiliar avenues**. It is about **how we would like to live in the future**, and how we respond to issues of the globalised world in both economy and in society.

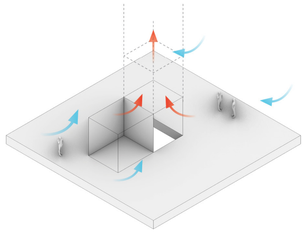
– **Germany's Sustainable Development Strategy**:
The Federal Government

IMPORTANT PARAMETERS



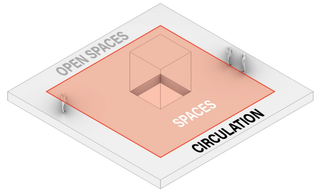
THEORETICAL FRAMEWORK

EXAMPLE



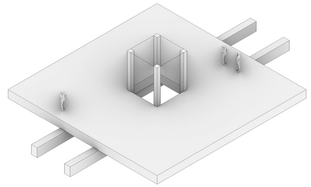
VENTILATION

The main function of the tubes are the ventilation of the spaces



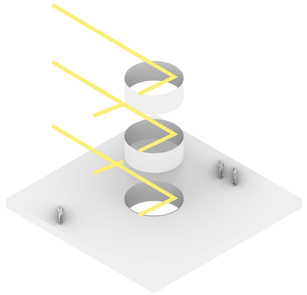
FLOORPLANNING

The location of the tubes can have influence on the floorplanning of the building



CONSTRUCTION

The tubes can play a role in the construction of the building, requiring little to no columns in the building, creating open floorplates



LIGHT

The hollow form of the tubes may allow for extra natural light to enter inside the building, or installed light can influence the light.





CELEBRATE ~~TECHNICAL~~ SUSTAINABLE METHOD




THANK YOU!