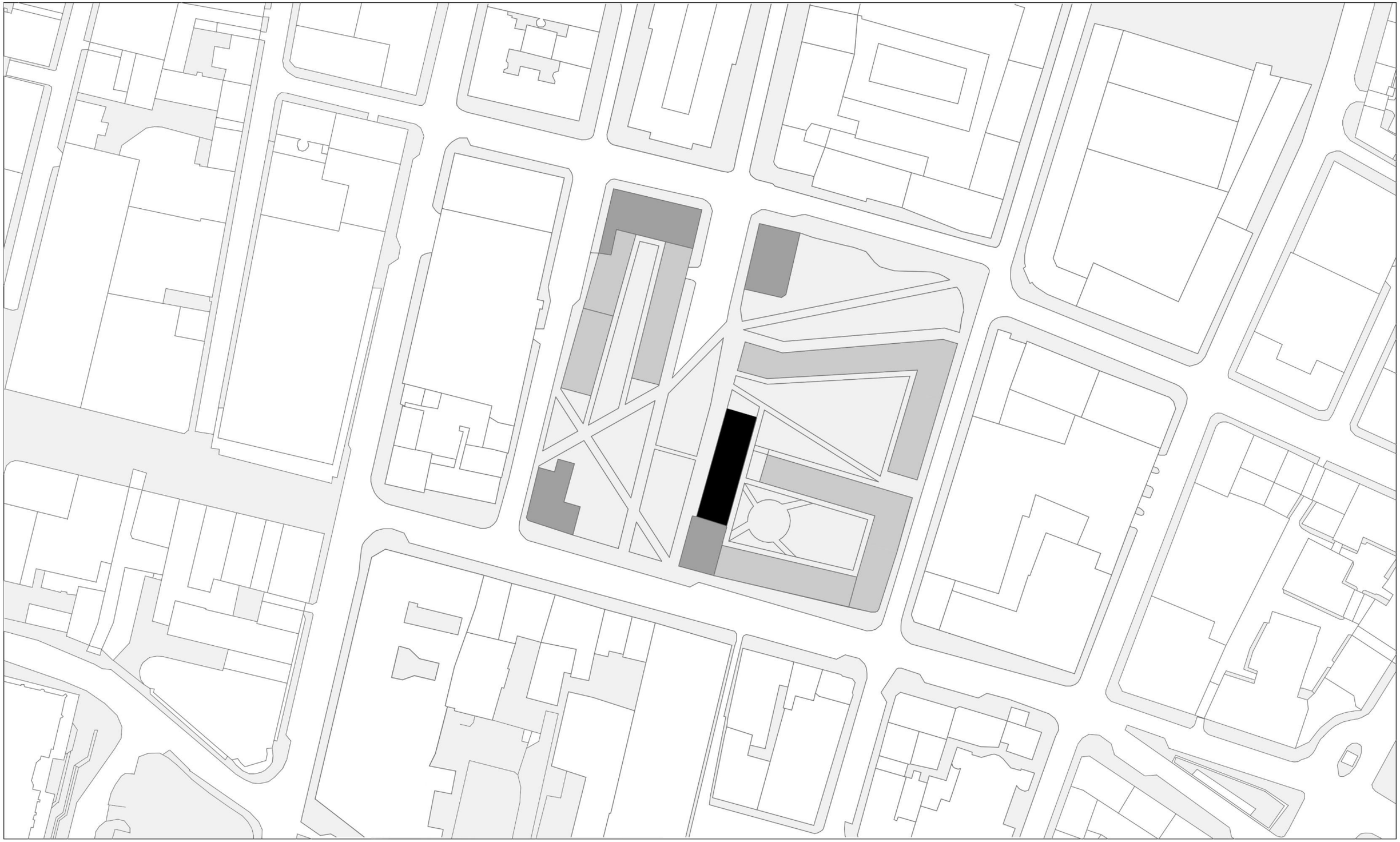
Environmental Strategy for Housing Design

Trongate – Candleriggs

Merchant City

Konrad Kolodziej

Location Plan



Scale 1:1250

0 10 20 30 40 50 60 70 80 90 100m

N

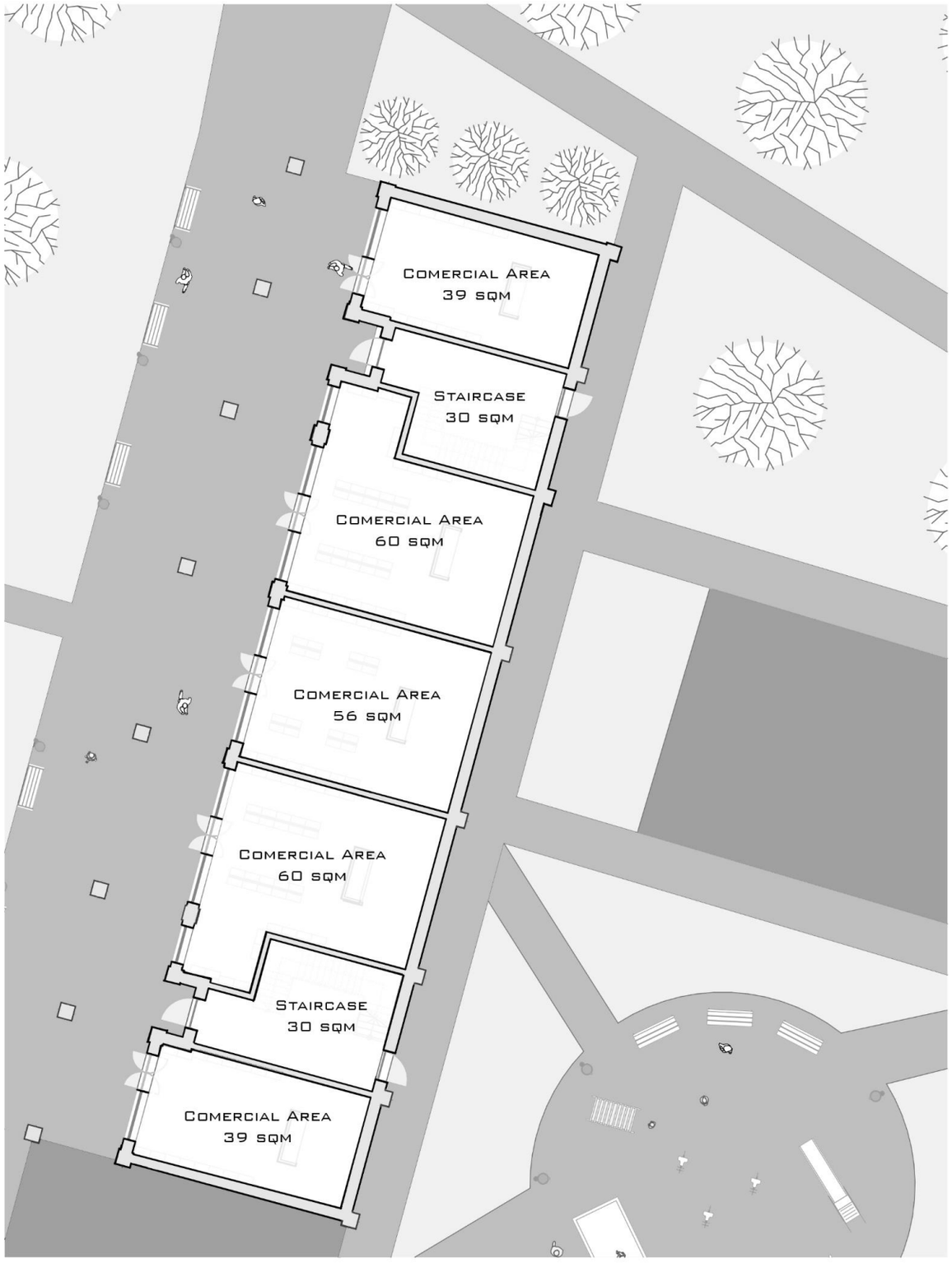
Site Plan

Scale 1:500 (Reduced)

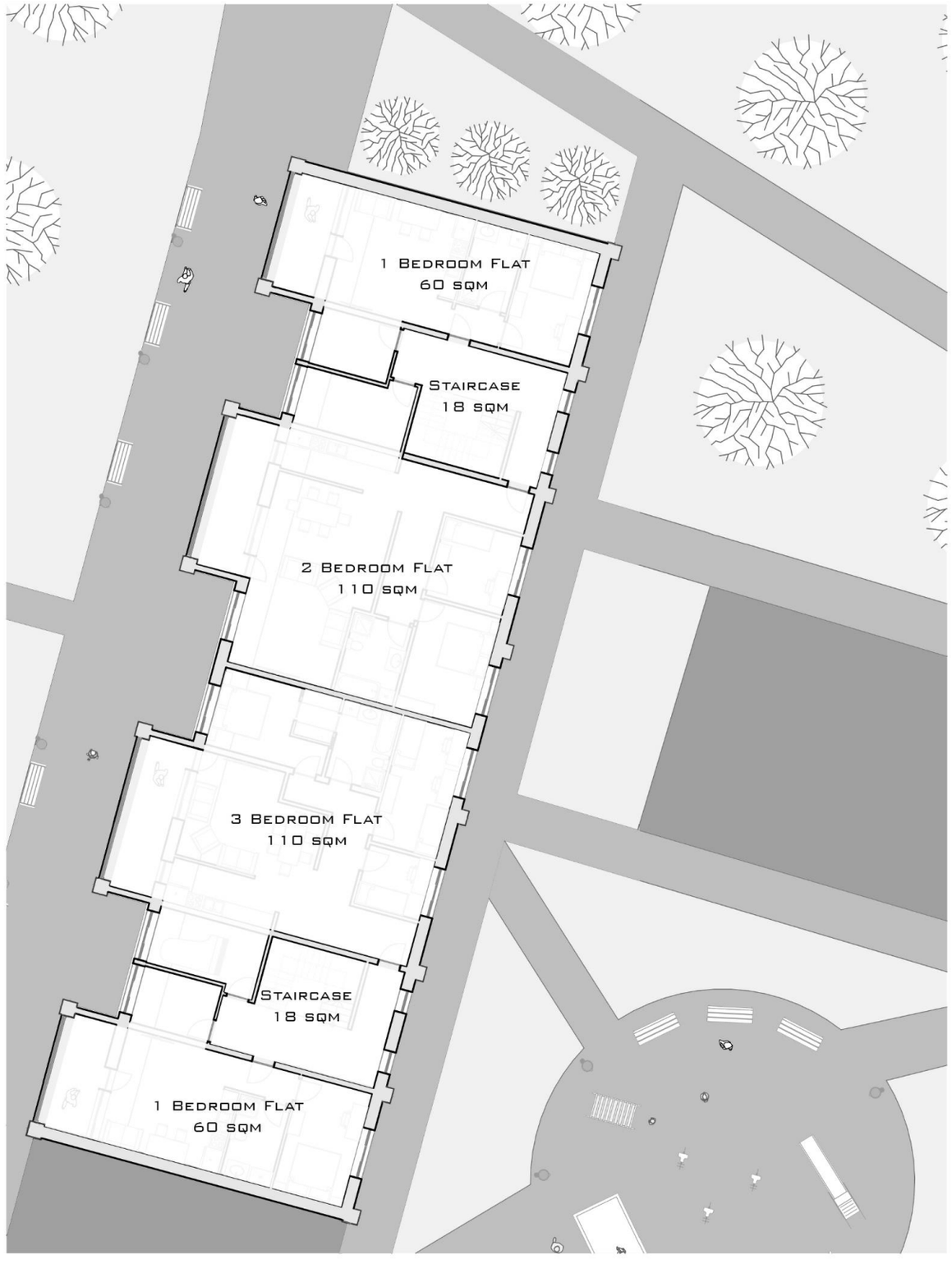
0 10 20 30 40 50 60 70 80 90 100 m

N

Block Plan



Ground Floor



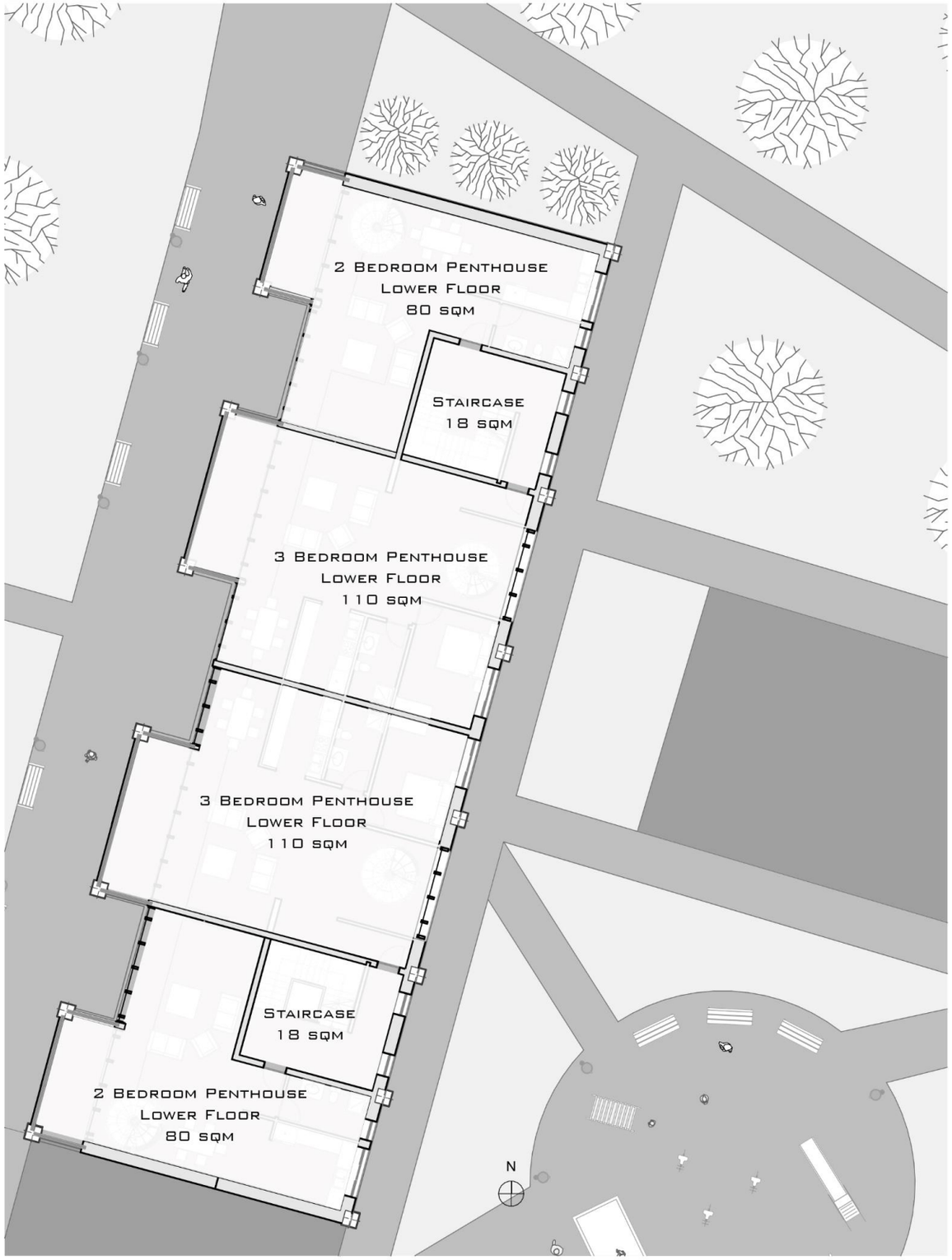
1-3 Floors

Scale 1:200

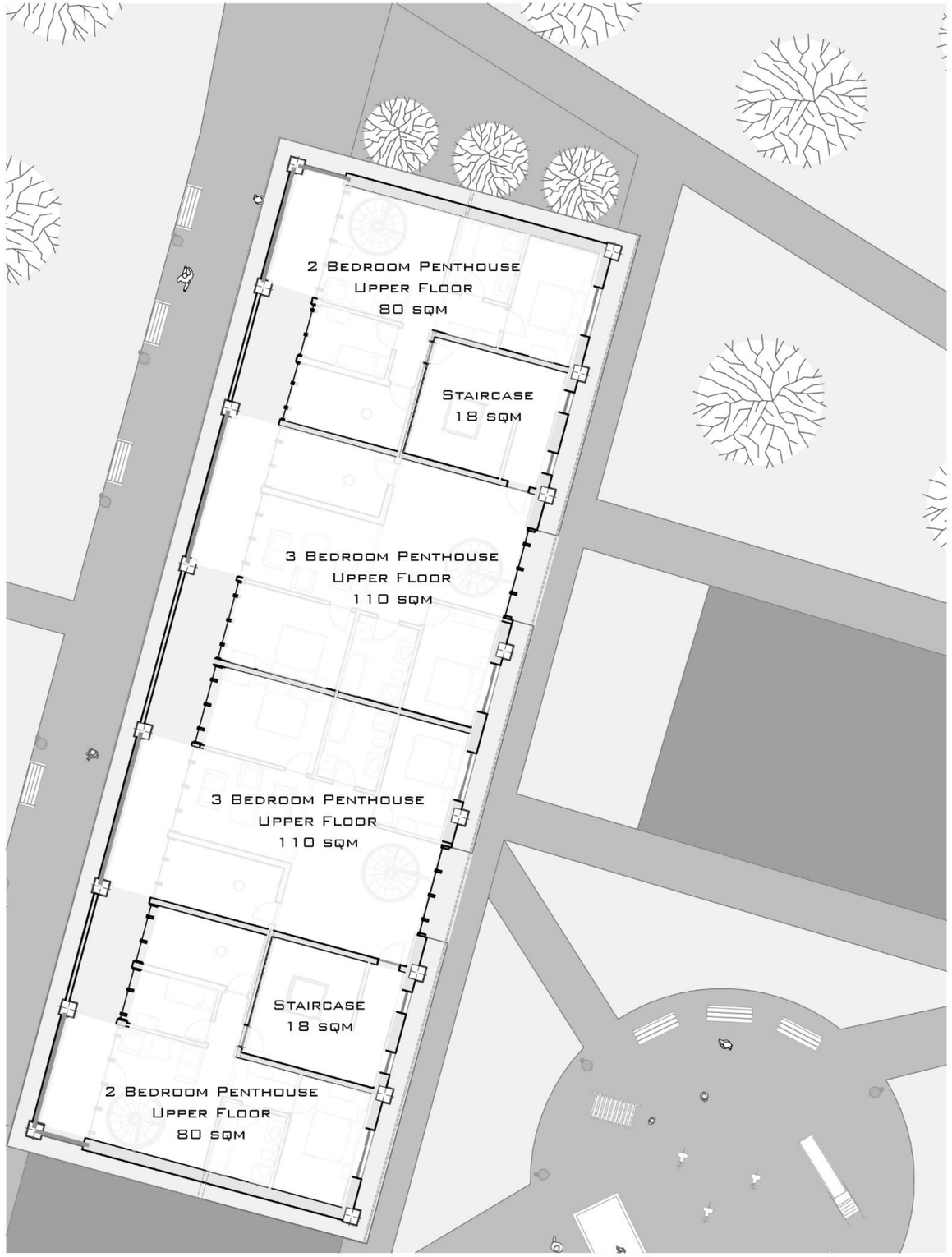
0 2 4 6 8 10 12 14 16 18 20 m

N

Block Plan



4th Floor



5th Floor

Comercial Area
60 sqm

Scale 1:200

0 2 4 6 8 10 12 14 16 18 20 m

N

West Elevation

Scale 1:100
0 1 2 3 4 5 6 7 8 9 10 m

East Elevation

Scale 1:100
0 1 2 3 4 5 6 7 8 9 10 m

Building Elevations (reduced)

West Facade
354 sqm of glazing
426 sqm of solid wall

East Facade
185 sqm of glazing
595 sqm of solid wall

North Elevation
195 sqm of solid wall

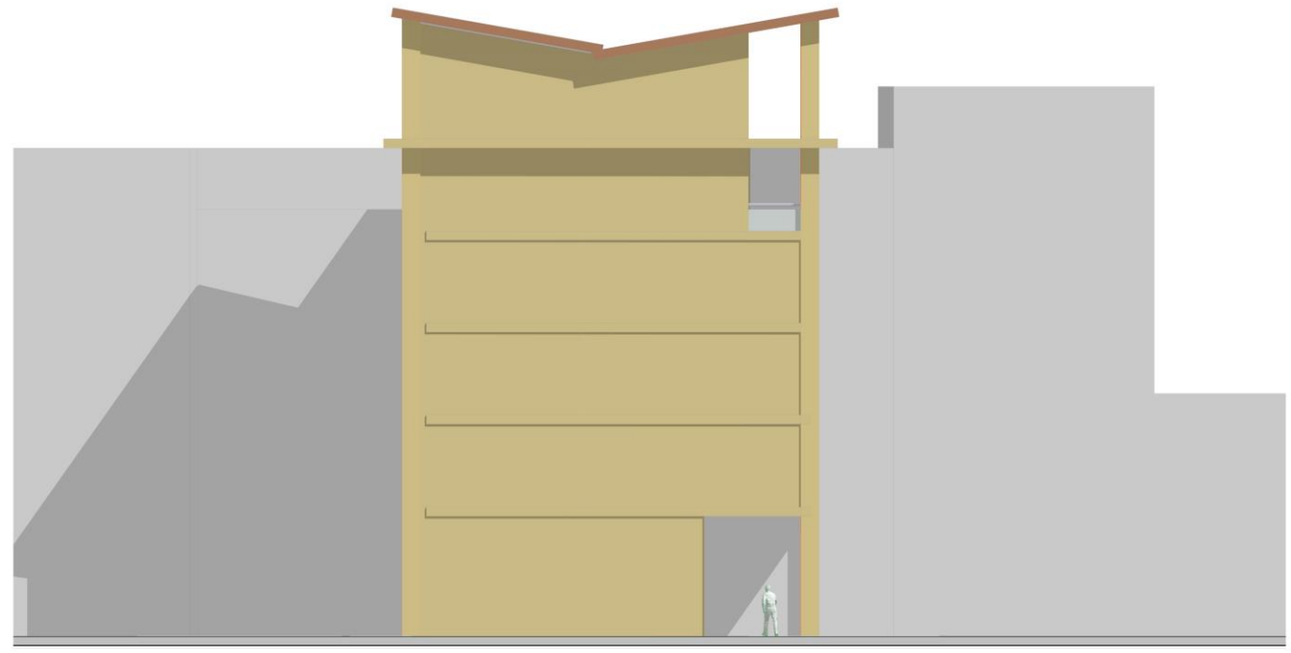
South Elevation
195 sqm of solid wall

Total Wall Area
1410 sqm
Total Glazed Area
540 sqm

Ventilation Losses		
Area of Building (m2)	440	
Building Height	20	
Volume of Building	8800	
Total Occupancy	50	
Fresh Air Rate (l/s/p)	10	
Total Fresh Air Required (l/s)	500	
Converting from l/s to m3/s	0,50	
Converting from m3/s to m3/hr	1800	
Converting m3/hr to ACH	0,20	

Roof Area:
460sqm

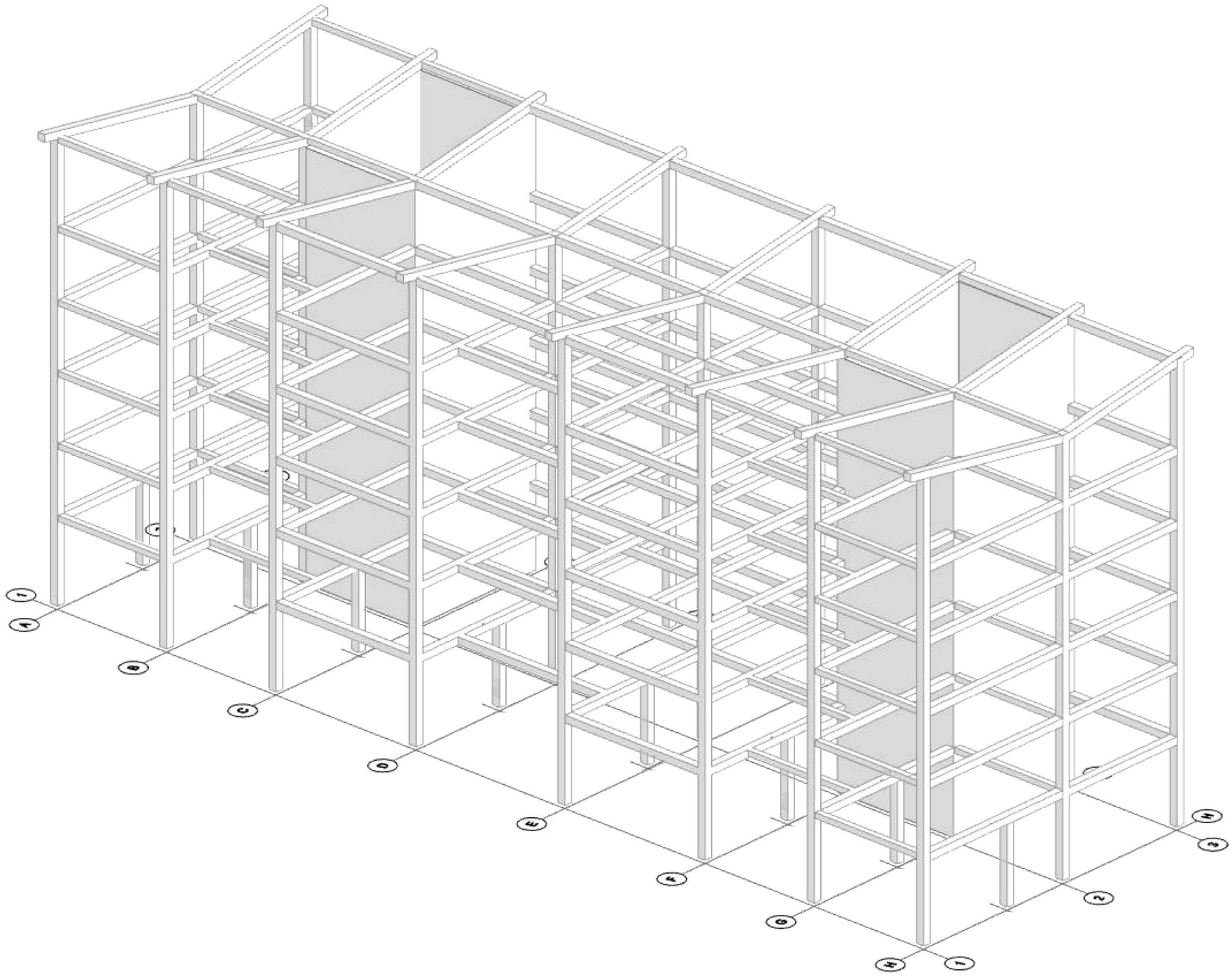
Occupancy:
50 people



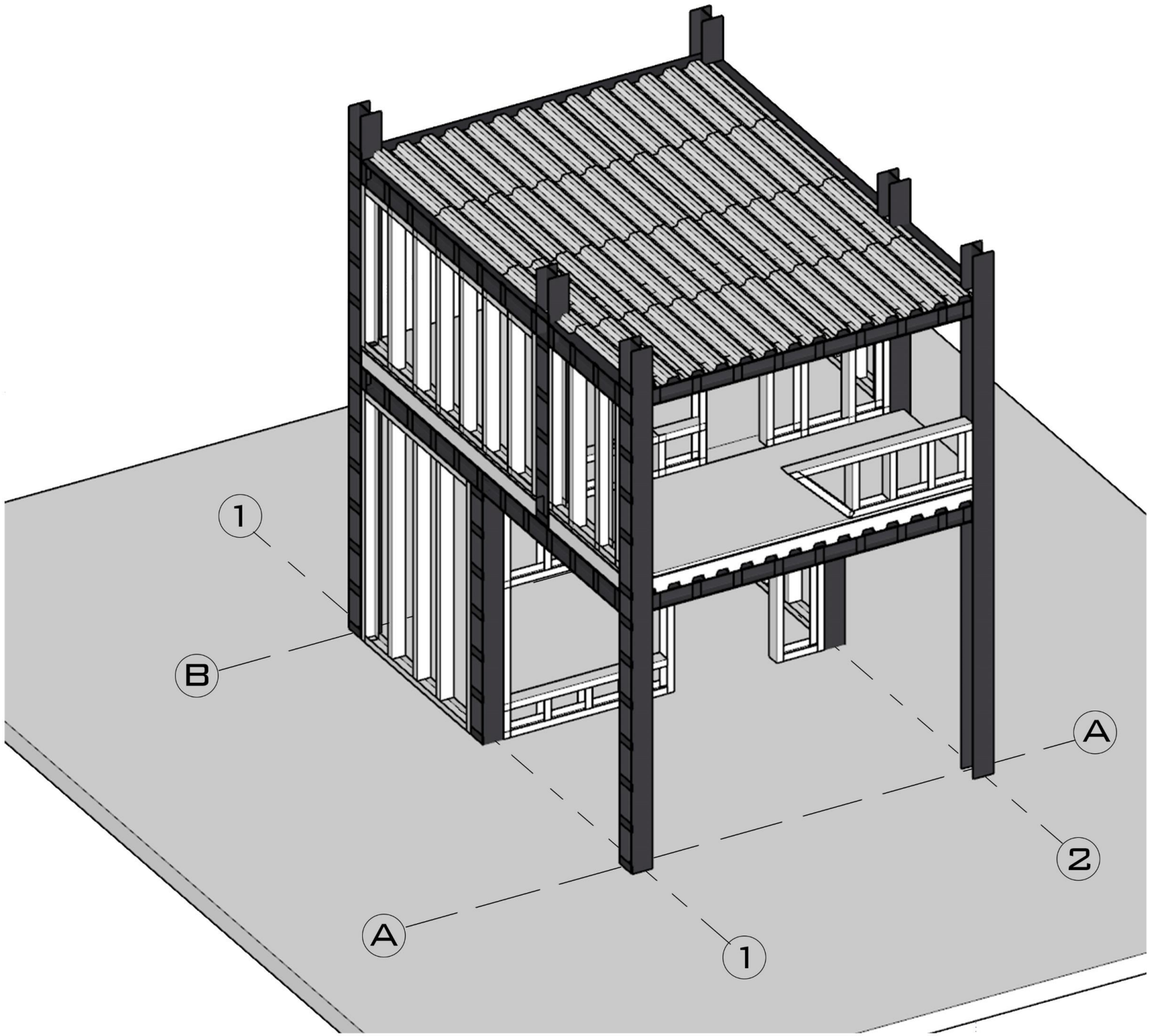
North Elevation

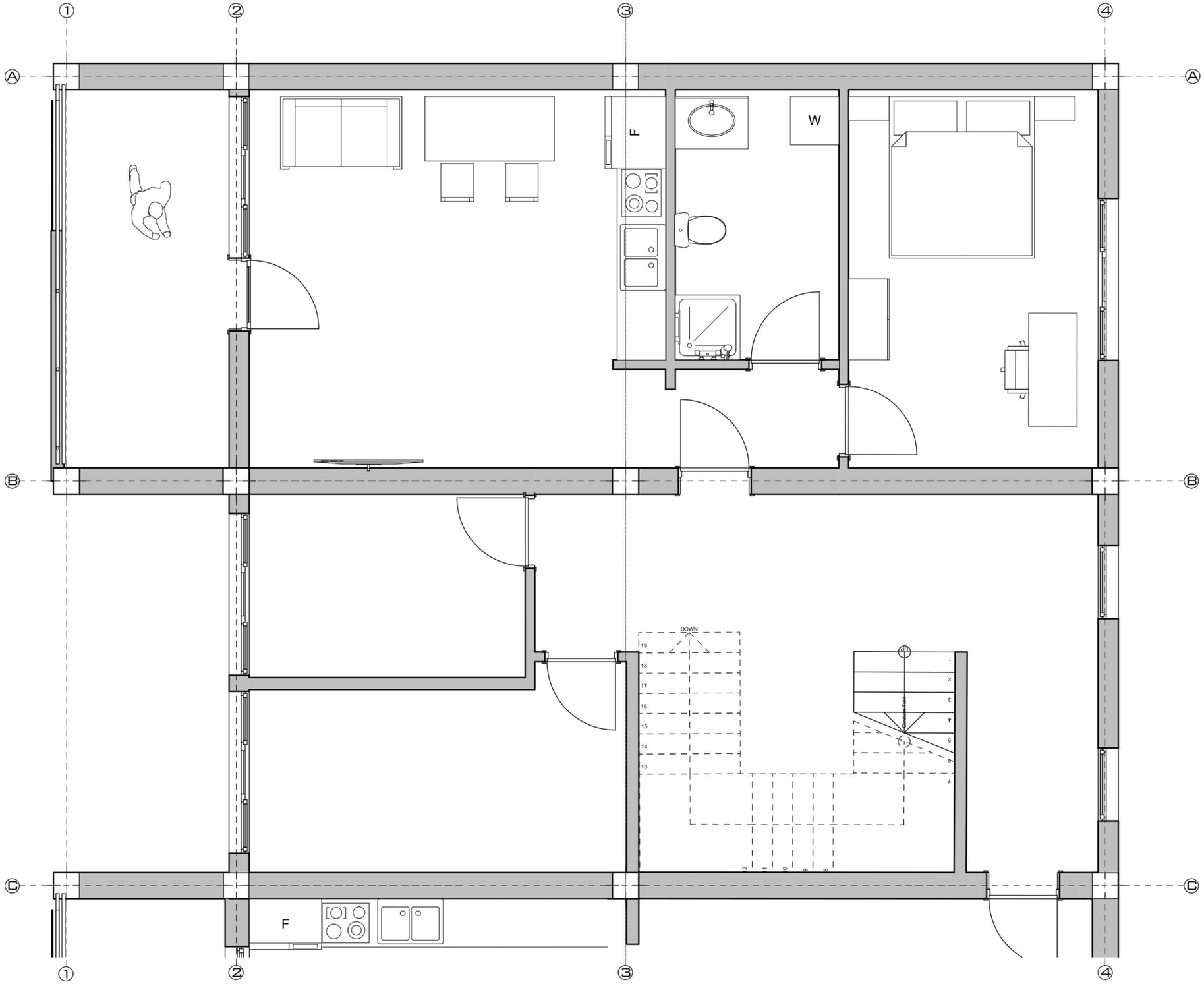
Scale 1:100
0 1 2 3 4 5 6 7 8 9 10 m

Structural diagram



Structural bay





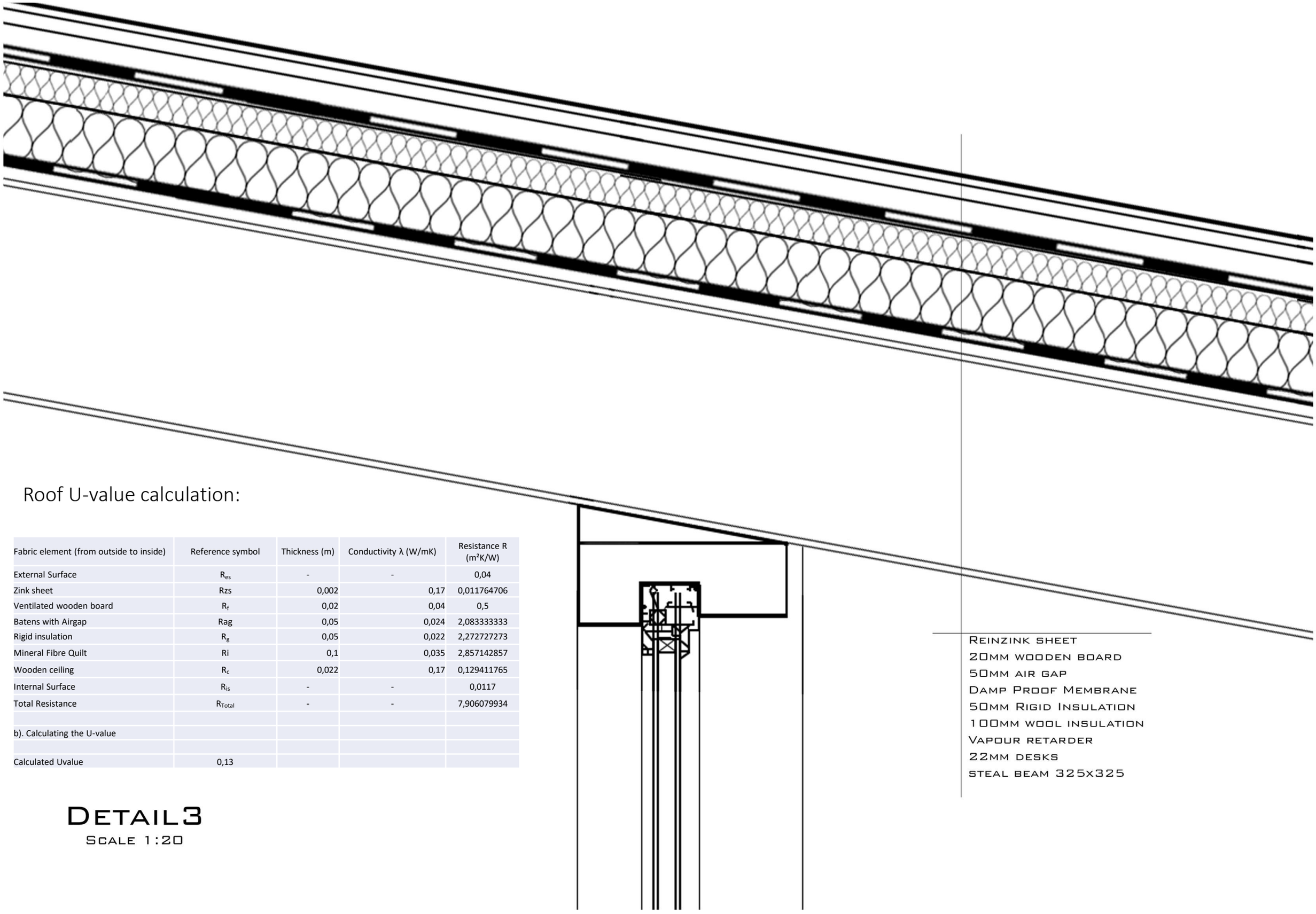
Scale 1:50

0 1 2 3 4 5 6 7 8 9 10 M

N

Part Plan

Scale 1:50



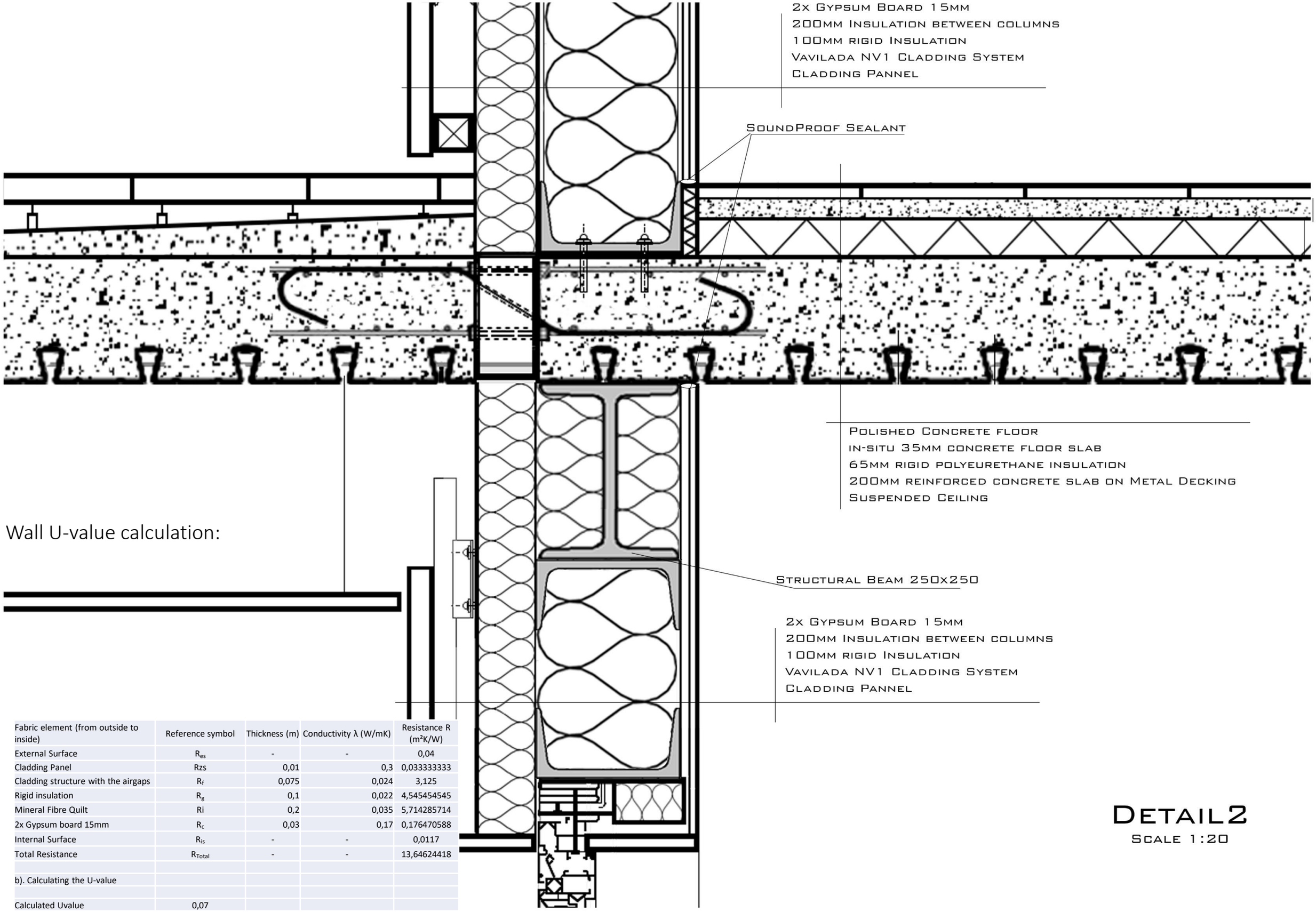
Roof U-value calculation:

Fabric element (from outside to inside)	Reference symbol	Thickness (m)	Conductivity λ (W/mK)	Resistance R (m²K/W)
External Surface	R_{es}	-	-	0,04
Zink sheet	Rzs	0,002	0,17	0,011764706
Ventilated wooden board	R_f	0,02	0,04	0,5
Batens with Airgap	Rag	0,05	0,024	2,083333333
Rigid insulation	R_g	0,05	0,022	2,272727273
Mineral Fibre Quilt	Ri	0,1	0,035	2,857142857
Wooden ceiling	R_c	0,022	0,17	0,129411765
Internal Surface	R_{is}	-	-	0,0117
Total Resistance	R_{Total}	-	-	7,906079934
b). Calculating the U-value				
Calculated Uvalue	0,13			

REINZINK SHEET
20MM WOODEN BOARD
50MM AIR GAP
DAMP PROOF MEMBRANE
50MM RIGID INSULATION
100MM WOOL INSULATION
VAPOUR RETARDER
22MM DESKS
STEAL BEAM 325X325

DETAIL3

SCALE 1:20

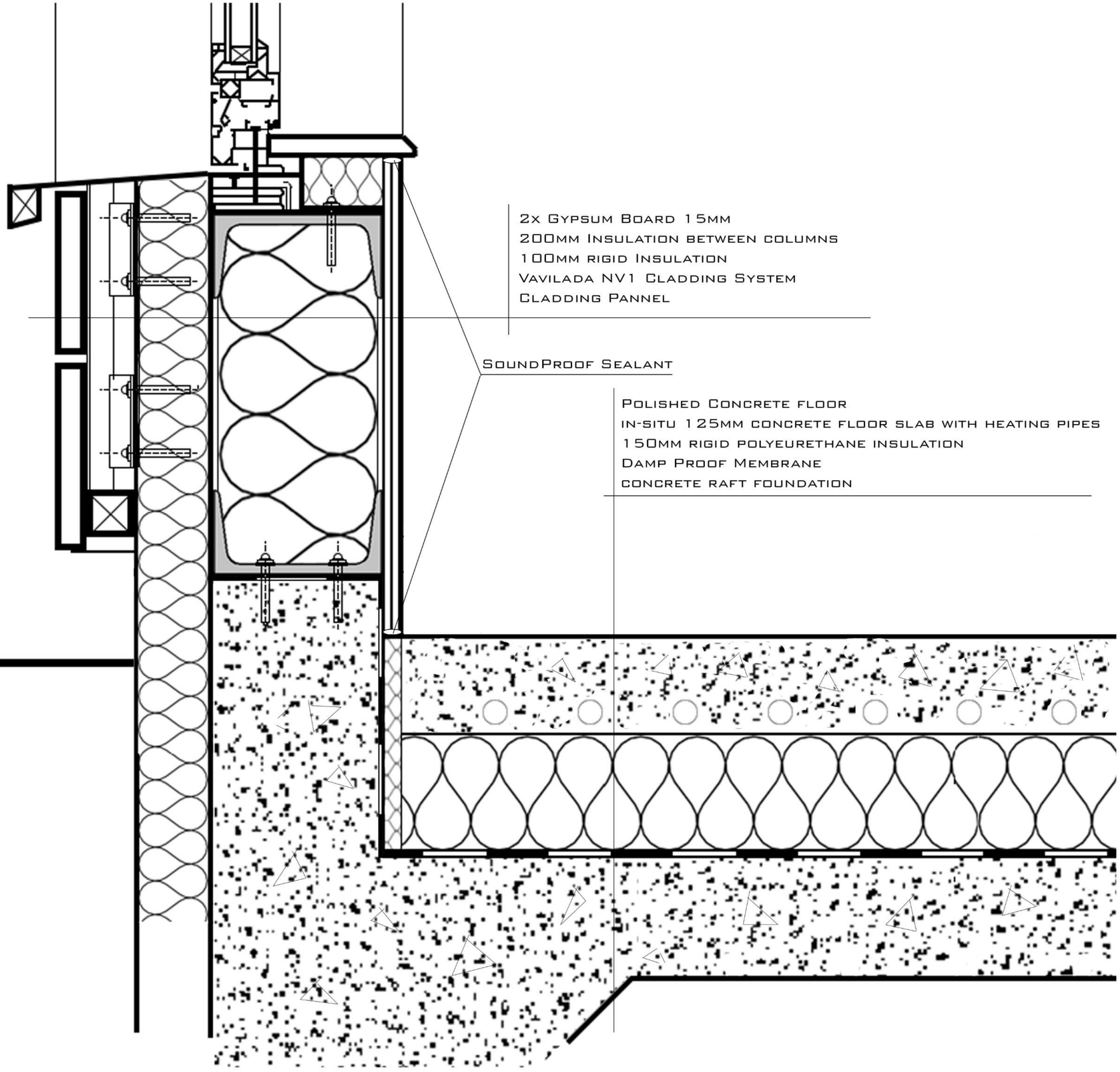


Wall U-value calculation:

Fabric element (from outside to inside)	Reference symbol	Thickness (m)	Conductivity λ (W/mK)	Resistance R (m^2K/W)
External Surface	R_{es}	-	-	0,04
Cladding Panel	Rzs	0,01	0,3	0,033333333
Cladding structure with the airgaps	R_f	0,075	0,024	3,125
Rigid insulation	R_g	0,1	0,022	4,545454545
Mineral Fibre Quilt	Ri	0,2	0,035	5,714285714
2x Gypsum board 15mm	R_c	0,03	0,17	0,176470588
Internal Surface	R_{is}	-	-	0,0117
Total Resistance	R_{Total}	-	-	13,64624418
b). Calculating the U-value				
Calculated Uvalue	0,07			

Detail2

Scale 1:20



Detail 1

Scale 1:20

Heatloss Calculations (Entire Building)

Fabric Losses			
Element	U-value (W/m2K)	Area (m2)	AU (W/K)
Roof	0,13	460	59,8
Wall	0,07	1410	98,7
Floor	0,18	0	0
Window	1	540	540
Total Fabric Loss (W/K)			698,5

Ventilation Losses	
Area of Building (m2)	440
Building Height	20
Volume of Building	8800
Total Occupancy	50
Fresh Air Rate (l/s/p)	10
Total Fresh Air Required (l/s)	500
Converting from l/s to m3/s	0,50
Converting from m3/s to m3/hr	1800
Converting m3/hr to ACH	0,20
Fresh Air Change Rate (ACH)	0,20
Ventilation Loss (W/K)	600
Heat Recovery Efficiency	0,8
Total Ventilation Loss W/K	120

Calculating Total Heat Loss	
Tint	21
Text	5
Temperature Difference	16
Total Fabric Loss	699
Total Ventilation Loss	120
Total Heat Loss (W)	13096

Total Ventilation Loss (W/K)	120
Total Fabric Loss (W/K)	698,5
Calculating U'	0,8185

Heating Energy Demand and Heatgains Calculation

Step 1: Calculating Monthly Heating Energy Demand

Using degrees days for Edinburgh

(source: www.degreedays.net (using temperature data from www.wunderground.com)

Month starting	Heating Degree Days
Jan	337
Feb	279
Mar	270
April	212
May	125
June	62
July	60
Aug	64
Sept	97
Oct	134
Nov	308
Dec	363

Total Ventilation Loss (W/K)	120
Total Fabric Loss (W/K)	698,5
Calculating U'	0,8185

Month	U' (kW)	Monthly Degree Days	Hours per day (Hours)	Monthly Heating Demand (kWh)
January	0,8185	337	24	6620,0
February	0,8185	279	24	5480,7
March	0,8185	270	24	5303,9
April	0,8185	212	24	4164,5
May	0,8185	125	24	2455,5
June	0,8185	62	24	1217,9
July	0,8185	60	24	1178,6
August	0,8185	64	24	1257,2
September	0,8185	97	24	1905,5
October	0,8185	134	24	2632,3
November	0,8185	308	24	6050,4
December	0,8185	363	24	7130,8
			ANNUAL TOTAL	45397,3

Step 2: Calculating Monthly Heat Gains

North Façade Area (m2)	195		Solar Gain Factor	0,62
East Façade Area (m2)	780			
South Façade Area (m2)	195			
West Façade Area (m2)	780			
North Glazing % (input as a decimal)	0			
East Glazing % (input as a decimal)	0,24			
South Glazing % (input as a decimal)	0			
West Glazing % (input as a decimal)	0,45			

Solar Cooling Loads (W/m2)	N	E	S	W
January	20	42	222	54
February	40	83	213	114
March	70	146	398	199
April	98	111	280	252
May	111	304	333	335
June	125	278	302	305
July	112	279	315	305
August	89	271	345	161
September	65	178	383	214
October	39	115	330	85
November	19	37	240	61
December	13	38	145	19

Month	(kW)	Monthly Sunlight Hours	Monthly Solar Gain (kWh)
January	16,626168	34,7	576,9280296
February	34,441992	59,3	2042,410126
March	60,251724	90,8	5470,856539
April	67,723344	141,9	9609,942514
May	108,186156	185,1	20025,25748
June	98,639892	183	18051,10024
July	98,755956	158,7	15672,57022
August	66,490164	137	9109,152468
September	67,230072	111	7462,537992
October	31,84506	71,9	2289,659814
November	17,569188	42	737,905896
December	8,545212	25,8	220,4664696
		Annual Solar Gains	91268,78778

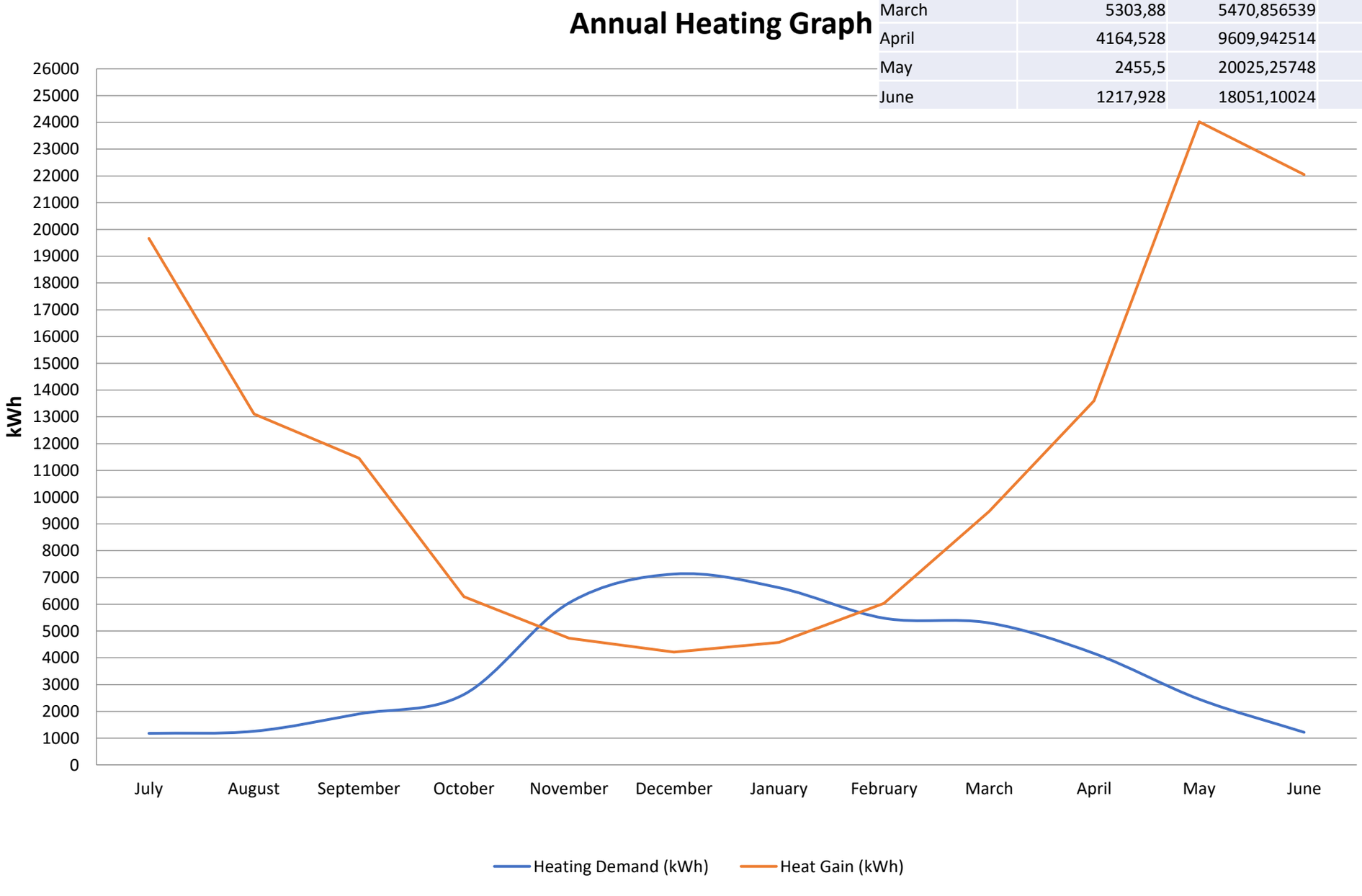
Casual Gains

	W	Occupancy Gain (W/P)
Lighting Gain (W/m2)	5	2200	90
Occupancy Load (number of people)	50	4500	
Equipment Gain (W/m2)	10	4400	
Total Casual Gains (W)		11100	

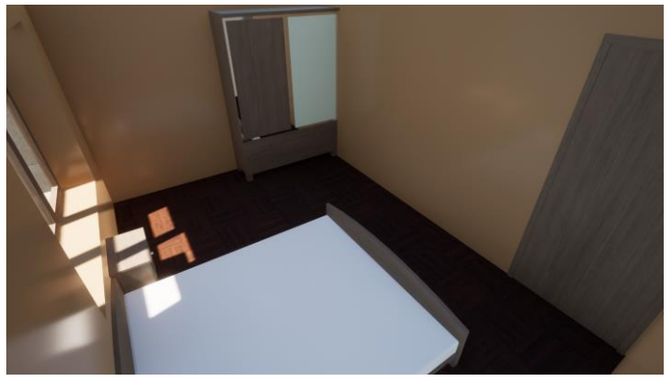
Month	(kW)	Monthly Occupied Hrs	Monthly Casual Gain (kWh)
January	11,1	360	3996
February	11,1	360	3996
March	11,1	360	3996
April	11,1	360	3996
May	11,1	360	3996
June	11,1	360	3996
July	11,1	360	3996
August	11,1	360	3996
September	11,1	360	3996
October	11,1	360	3996
November	11,1	360	3996
December	11,1	360	3996
		Annual Casual Gains	47952

Annual Heating Graph

Month	Monthly Heating Demand	Solar Gain	Casual Gain	Monthly Heat Gains	Heating Season
	(kWh)	(kWh)	(kWh)	(kWh)	Hrs
July	1178,64	15672,57022	3996	19668,57022	0
August	1257,216	9109,152468	3996	13105,15247	0
September	1905,468	7462,537992	3996	11458,53799	0
October	2632,296	2289,659814	3996	6285,659814	0
November	6050,352	737,905896	3996	4733,905896	1
December	7130,772	220,4664696	3996	4216,46647	1
January	6620,028	576,9280296	3996	4572,92803	1
February	5480,676	2042,410126	3996	6038,410126	0
March	5303,88	5470,856539	3996	9466,856539	0
April	4164,528	9609,942514	3996	13605,94251	0
May	2455,5	20025,25748	3996	24021,25748	0
June	1217,928	18051,10024	3996	22047,10024	0



Heatloss Calculations (1 Bedroom flat south located)



Fabric Losses			
Element	U-value (W/m2K)	Area (m2)	AU (W/K)
Roof	0,13	0	0
Wall	0,07	45	3,15
Floor	0	0	0
Window	1	8	8
Total Fabric Loss (W/K)			11,15

Ventilation Losses	
Area of Building (m2)	45
Building Height	2,65
Volume of Building	119,25
Total Occupancy	2
Fresh Air Rate (l/s/p)	10
Total Fresh Air Required (l/s)	20
Converting from l/s to m3/s	0,02
Converting from m3/s to m3/hr	72
Converting m3/hr to ACH	0,60
Fresh Air Change Rate (ACH)	0,60
Ventilation Loss (W/K)	24
Heat Recovery Efficiency	0,8
Total Ventilation Loss W/K	5

Calculating Total Heat Loss	
Tint	21
Text	5
Temperature Difference	16
Total Fabric Loss	11
Total Ventilation Loss	5
Total Heat Loss (W)	255

Total Ventilation Loss (W/K)	5
Total Fabric Loss (W/K)	11,15
Calculating U'	0,01595

Heating Energy Demand and Heatgains Calculation

Step 1: Calculating Monthly Heating Energy Demand

Using degrees days for Edinburgh (source: www.degreedays.net (using temperature data from www.wunderground.com)

Month starting	Heating Degree Days
Jan	337
Feb	279
Mar	270
April	212
May	125
June	62
July	60
Aug	64
Sept	97
Oct	134
Nov	308
Dec	363

Total Ventilation Loss (W/K)	5
Total Fabric Loss (W/K)	11,15
Calculating U'	0,01595

Month	U' (kW)	Monthly Degree Days	Hours per day (Hours)	Monthly Heating Demand (kWh)
January	0,01595	337	24	129,0
February	0,01595	279	24	106,8
March	0,01595	270	24	103,4
April	0,01595	212	24	81,2
May	0,01595	125	24	47,9
June	0,01595	62	24	23,7
July	0,01595	60	24	23,0
August	0,01595	64	24	24,5
September	0,01595	97	24	37,1
October	0,01595	134	24	51,3
November	0,01595	308	24	117,9
December	0,01595	363	24	139,0
			ANNUAL TOTAL	884,7

Step 2: Calculating Monthly Heat Gains

North Façade Area (m2)	0		Solar Gain Factor	0,62
East Façade Area (m2)	12,27			
South Façade Area (m2)	26,5			
West Façade Area (m2)	12,27			
North Glazing % (input as a decimal)	0			
East Glazing % (input as a decimal)	0,25			
South Glazing % (input as a decimal)	0			
West Glazing % (input as a decimal)	0,4			

Solar Cooling Loads (W/m2)	N	E	S	W
January	20	42	222	54
February	40	83	213	114
March	70	146	398	199
April	98	111	280	252
May	111	304	333	335
June	125	278	302	305
July	112	279	315	305
August	89	271	345	161
September	65	178	383	214
October	39	115	330	85
November	19	37	240	61
December	13	38	145	19

Month	(kW)	Monthly Sunlight Hours	Monthly Solar Gain (kWh)
January	0,24419754	34,7	8,473654638
February	0,50475099	59,3	29,93173371
March	0,88321914	90,8	80,19629791
April	0,97793127	141,9	138,7684472
May	1,597554	185,1	295,7072454
June	1,4568171	183	266,5975293
July	1,45871895	158,7	231,4986974
August	1,00531791	137	137,7285537
September	0,98972274	111	109,8592241
October	0,47736435	71,9	34,32249677
November	0,25598901	42	10,75153842
December	0,13008654	25,8	3,356232732
		Annual Solar Gains	1347,191651

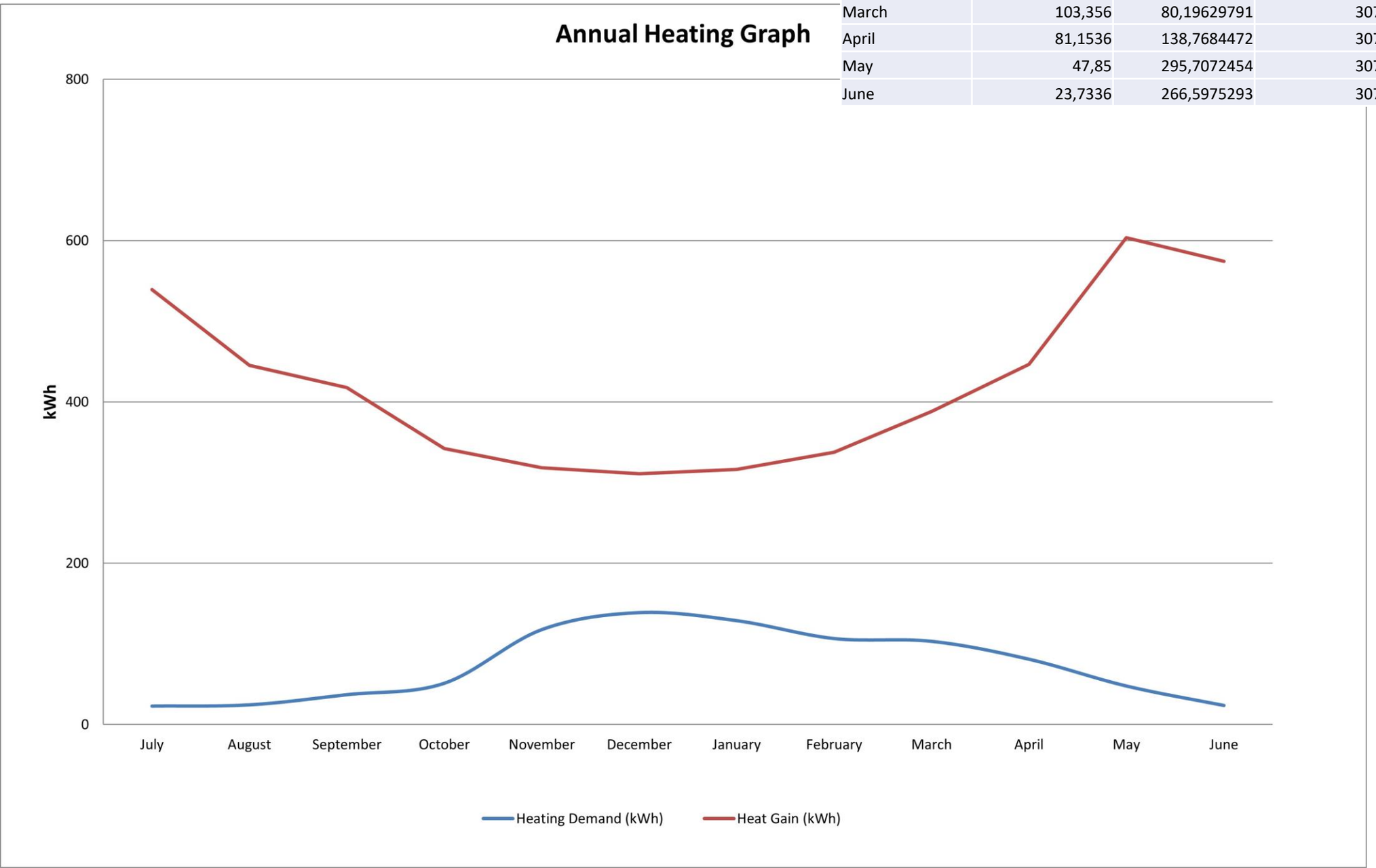
Casual Gains

		W	Occupancy Gain (W/P)
Lighting Gain (W/m2)	5	225	90
Occupancy Load (number of people)	2	180	
Equipment Gain (W/m2)	10	450	
Total Casual Gains (W)		855	

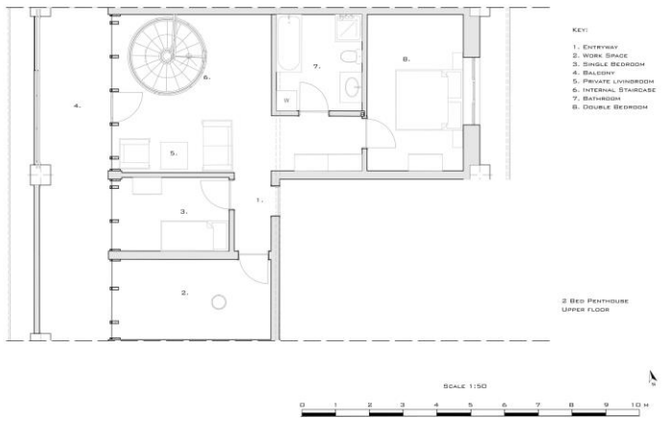
Month	(kW)	Monthly Occupied Hrs	Monthly Casual Gain (kWh)
January	0,855	360	307,8
February	0,855	360	307,8
March	0,855	360	307,8
April	0,855	360	307,8
May	0,855	360	307,8
June	0,855	360	307,8
July	0,855	360	307,8
August	0,855	360	307,8
September	0,855	360	307,8
October	0,855	360	307,8
November	0,855	360	307,8
December	0,855	360	307,8
		Annual Casual Gains	3693,6

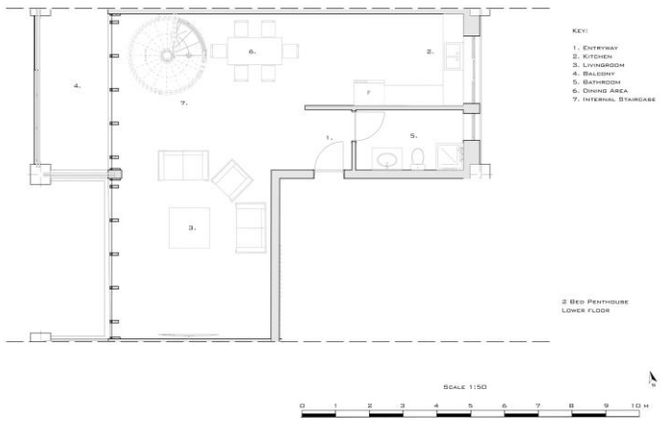
Annual Heating Graph

Month	Monthly Heating Demand	Solar Gain	Casual Gain	Monthly Heat Gains	Heating Season
	(kWh)	(kWh)	(kWh)	(kWh)	Hrs
July	22,968	231,4986974	307,8	539,2986974	0
August	24,4992	137,7285537	307,8	445,5285537	0
September	37,1316	109,8592241	307,8	417,6592241	0
October	51,2952	34,32249677	307,8	342,1224968	0
November	117,9024	10,75153842	307,8	318,5515384	0
December	138,9564	3,356232732	307,8	311,1562327	0
January	129,0036	8,473654638	307,8	316,2736546	0
February	106,8012	29,93173371	307,8	337,7317337	0
March	103,356	80,19629791	307,8	387,9962979	0
April	81,1536	138,7684472	307,8	446,5684472	0
May	47,85	295,7072454	307,8	603,5072454	0
June	23,7336	266,5975293	307,8	574,3975293	0



Heatloss Calculations (2 Bedroom Penthouse north located)





Fabric Losses			
Element	U-value (W/m2K)	Area (m2)	AU (W/K)
Roof	0,13	70	9,1
Wall	0,07	78,4	5,488
Floor	0	0	0
Window	1	65,3	65,3
Total Fabric Loss (W/K)			79,888

Ventilation Losses	
Area of Building (m2)	70
Building Height	6
Volume of Building	420
Total Occupancy	4
Fresh Air Rate (l/s/p)	10
Total Fresh Air Required (l/s)	40
Converting from l/s to m3/s	0,04
Converting from m3/s to m3/hr	144
Converting m3/hr to ACH	0,34
Fresh Air Change Rate (ACH)	0,34
Ventilation Loss (W/K)	48
Heat Recovery Efficiency	0,8
Total Ventilation Loss W/K	10

Calculating Total Heat Loss	
Tint	21
Text	5
Temperature Difference	16
Total Fabric Loss	80
Total Ventilation Loss	10
Total Heat Loss (W)	1432

Total Ventilation Loss (W/K)	10
Total Fabric Loss (W/K)	79,888
Calculating U'	0,089488

Heating Energy Demand and Heatgains Calculation

Step 1: Calculating Monthly Heating Energy Demand

Using degrees days for Edinburgh (source: www.degreedays.net (using temperature data from www.wunderground.com)

Month starting	Heating Degree Days
Jan	337
Feb	279
Mar	270
April	212
May	125
June	62
July	60
Aug	64
Sept	97
Oct	134
Nov	308
Dec	363

Total Ventilation Loss (W/K)	10
Total Fabric Loss (W/K)	79,888
Calculating U'	0,089488

Month	U' (kW)	Monthly Degree Days	Hours per day (Hours)	Monthly Heating Demand (kWh)
January	0,089488	337	24	723,8
February	0,089488	279	24	599,2
March	0,089488	270	24	579,9
April	0,089488	212	24	455,3
May	0,089488	125	24	268,5
June	0,089488	62	24	133,2
July	0,089488	60	24	128,9
August	0,089488	64	24	137,5
September	0,089488	97	24	208,3
October	0,089488	134	24	287,8
November	0,089488	308	24	661,5
December	0,089488	363	24	779,6
			ANNUAL TOTAL	4963,4

Step 2: Calculating Monthly Heat Gains

North Façade Area (m2)	57		Solar Gain Factor	0,62
East Façade Area (m2)	28,6			
South Façade Area (m2)	0			
West Façade Area (m2)	58,1			
North Glazing % (input as a decimal)	0			
East Glazing % (input as a decimal)	0,25			
South Glazing % (input as a decimal)	0			
West Glazing % (input as a decimal)	1			

Solar Cooling Loads (W/m2)	N	E	S	W
January	20	42	222	54
February	40	83	213	114
March	70	146	398	199
April	98	111	280	252
May	111	304	333	335
June	125	278	302	305
July	112	279	315	305
August	89	271	345	161
September	65	178	383	214
October	39	115	330	85
November	19	37	240	61
December	13	38	145	19

Month	(kW)	Monthly Sunlight Hours	Monthly Solar Gain (kWh)	
January	2,131374	34,7	73,9586778	
February	4,474447	59,3	265,3347071	
March	7,815596	90,8	709,6561168	
April	9,569607	141,9	1357,927233	
May	13,415002	185,1	2483,11687	
June	12,219084	183	2236,092372	
July	12,223517	158,7	1939,872148	
August	7,000885	137	959,121245	
September	8,497782	111	943,253802	
October	3,571665	71,9	256,8027135	
November	2,361363	42	99,177246	
December	0,852872	25,8	22,0040976	
		Annual Solar Gains	11346,31723	

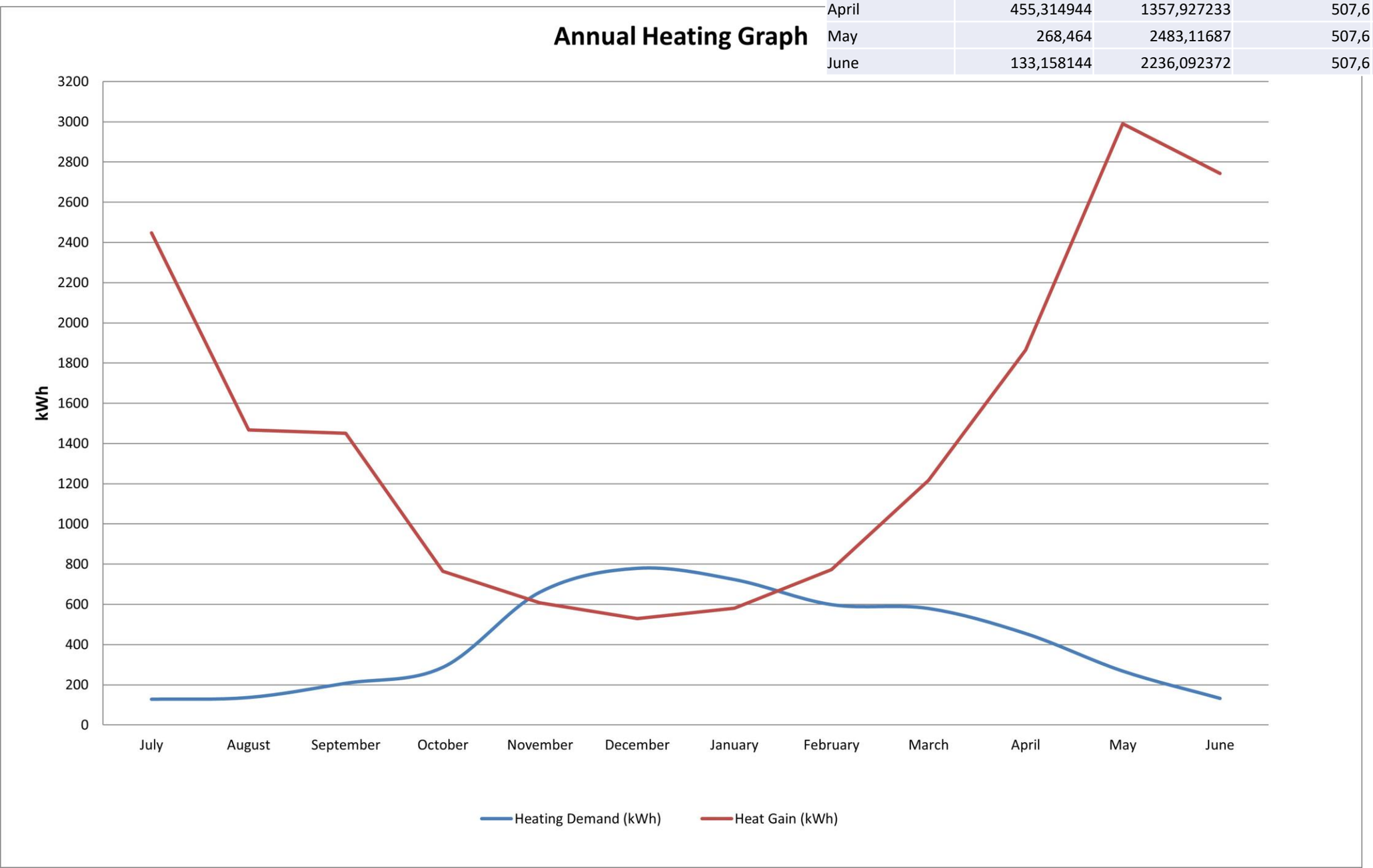
Casual Gains

	W	Occupancy Gain (W/P)
Lighting Gain (W/m2)	5	350
Occupancy Load (number of people)	4	360
Equipment Gain (W/m2)	10	700
Total Casual Gains (W)		1410

Month	(kW)	Monthly Occupied Hrs	Monthly Casual Gain (kWh)	
January	1,41	360	507,6	
February	1,41	360	507,6	
March	1,41	360	507,6	
April	1,41	360	507,6	
May	1,41	360	507,6	
June	1,41	360	507,6	
July	1,41	360	507,6	
August	1,41	360	507,6	
September	1,41	360	507,6	
October	1,41	360	507,6	
November	1,41	360	507,6	
December	1,41	360	507,6	
		Annual Casual Gains	6091,2	

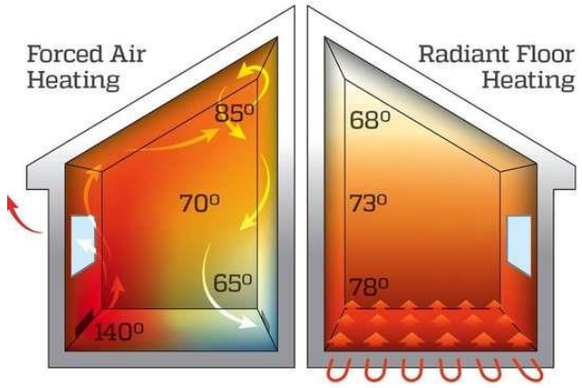
Annual Heating Graph

Month	Monthly Heating Demand (kWh)	Solar Gain (kWh)	Casual Gain (kWh)	Monthly Heat Gains (kWh)	Heating Season Hrs
July	128,86272	1939,872148	507,6	2447,472148	0
August	137,453568	959,121245	507,6	1466,721245	0
September	208,328064	943,253802	507,6	1450,853802	0
October	287,793408	256,8027135	507,6	764,4027135	0
November	661,495296	99,177246	507,6	606,777246	1
December	779,619456	22,0040976	507,6	529,6040976	1
January	723,778944	73,9586778	507,6	581,5586778	1
February	599,211648	265,3347071	507,6	772,9347071	0
March	579,88224	709,6561168	507,6	1217,256117	0
April	455,314944	1357,927233	507,6	1865,527233	0
May	268,464	2483,11687	507,6	2990,71687	0
June	133,158144	2236,092372	507,6	2743,692372	0



Heating and Cooling Strategy

Majority of the building are fitted with traditional radiator heating system, mostly run on fossil fuels such as gas which has to be gone by 2030. Modern radiators are able to run on renewable electricity from the grid. However radiators cannot distribute heat equally throughout the room creating cold spots in the room and they are operating on much higher temperatures making this technology less efficient than ptroperly designed underfloor heating.
Many building designed with electric floor heating are missing an additional function which could be provided by underfloor water heating. The same pipework system which supply heat during cold season can be used to cool the structure during hot seasons. Floor cooling needs less energy as differences between temperatures of the medium (water) and the environment is much smaller than temperature differences in air-condition. Also there can be problem with cold air standing low (close to the floor's surface) where good solution can be mechanical ventilation to achieve optimal air movement



Floor heating/cooling strategy

Pros:

- More efficient than traditional heating
- Can provide cooling replacing for less efficient air-condition
- More space (design freedom)
- Works with all types of floor covering

Cons:

- Initial cost of construction is higher
- Taking more time to install than different stretegies
- Thickness of floor is bigger

Traditional radiator heating

Pros:

- Initial cost of instalation is much cheaper than for FH
- Easier and quicker to install
- No need to consider a floor depth
- Works with all types of floor covering

Cons:

- Can deplete oxygen level
- Heat and collision hazard
- Less efficient due to medium (water) high temperatures
- Taking a certain amount of space

Air-Condition

Pros:

- Increase in our productivity
- Protection against heat strokes
- Protection against insects
- Assists in excluding external alergens like pollen
- Good installation and maintenance of A/C renews and enhances the quality of air

Cons:

- Breathing ground for bacteria
- Can weaken the immune system
- Needs a lot of energy
- Can be costly
- May contribute to ozone depletion

Floor Heating/Cooling Diagrams

Heating during cold season

Cooling during hot season

Section A-A
(reduced)

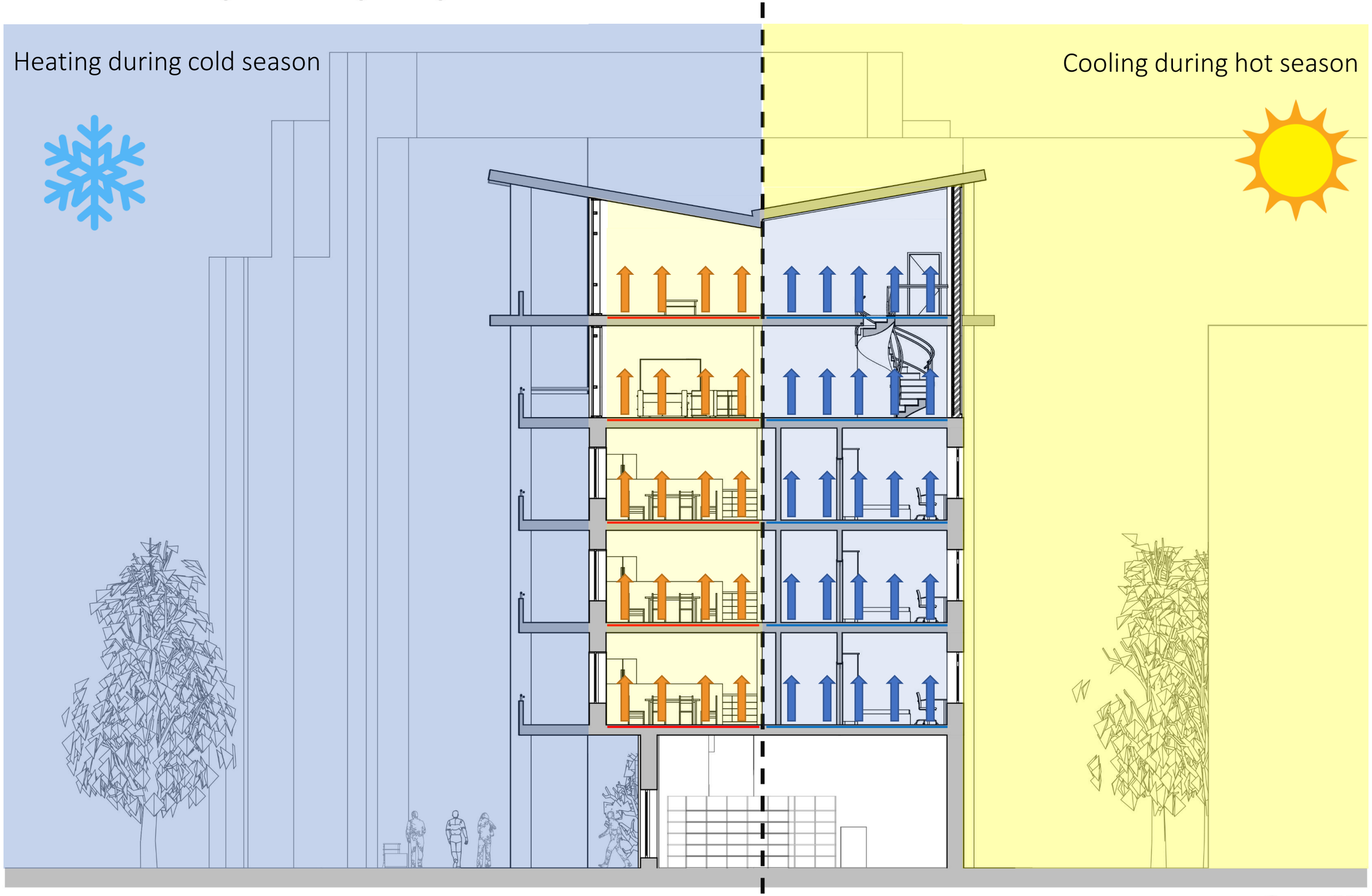
Scale 1:100

0 1 2 3 4 5 6 7 8 9 10 m

Floor Heating/Cooling Diagrams

Heating during cold season

Cooling during hot season



Section B-B

Scale 1:100

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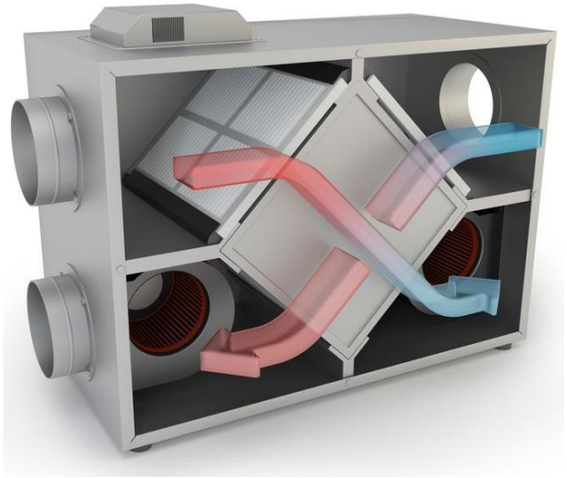
Ventilation Strategy

A heat recovery system (also called HRV or MVHR) works via a heat recovery ventilation unit. It is increasingly used to reduce the heating and cooling demands of buildings. This is because HRV draws the heat from the extracted air and passes it to the air which is being filtered in from outside. This way, the system makes use of what already exists as well as reduces our collective impact on the environment, and that includes the amount of heat we lose to the environment daily. Having an airtight building and good ventilation is important to avoid poor indoor air quality which can cause some respiratory problems. HRV will extract the moist, stale air from all the wet rooms and replace it with clean, filtered, fresh, warm air without letting the heat escape. The big volume of my building requires a big amount of fresh air (1800 m3/hr) and HRV provides an opportunity to reduce ventilation loss from 600 W/K to 120 W/K.



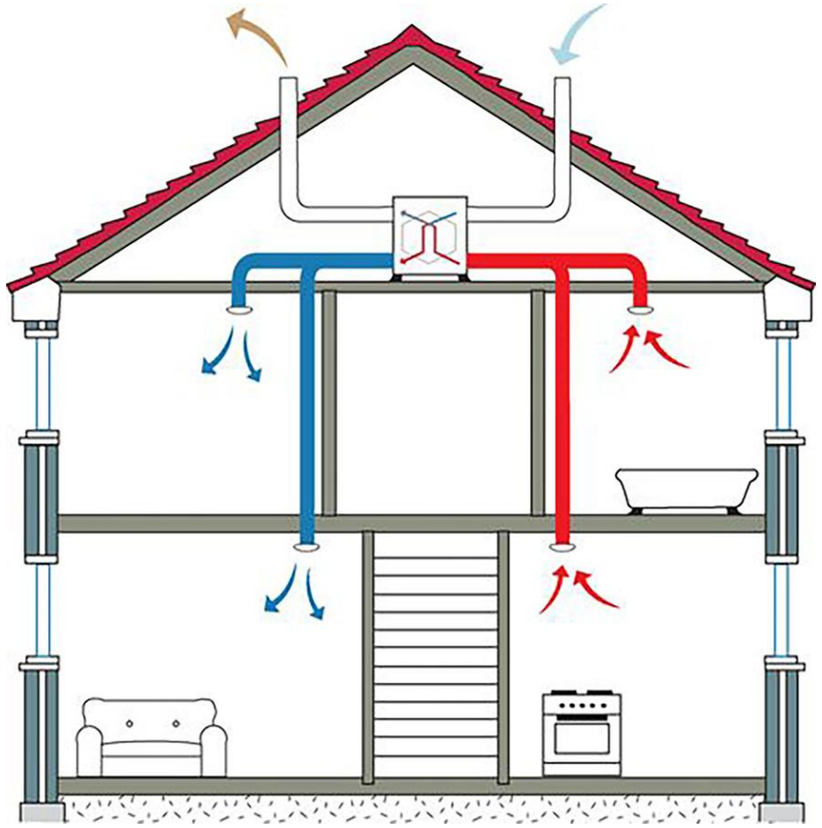
Mechanical Ventilation with Heat Recovery system

Pros:

- Better air quality and filtration
- Constant suply of fresh and filtered air to your home
- Reduces heating cost
- Lowers humidity and condensation
- Can recover almost 95% of heat losses caused by ventilation

Cons:

- Maintenance – filters need to be changed each 6 months
- Price – High initial cost
- Need some space for unit and ducting runs



Ventilation Strategy
Mechanical Ventilation
with Heat Recovery System

Floors 1-3

Key:

1. Staircase

1 Bedroom Flat
2.1 Entryway
2.2 Kitchen
2.3 Living Room
2.4 Balcony
2.5 Bathroom
2.6 Double Bedroom
2.7 Work space

3 Bedroom Flat
3,1 Entryway
3,2 Kitchen
3,3 Living Room
3,4 Balcony
3,5 Bathroom
3.6 Double Bedroom
3.7 Double Bedroom
3.8 Single Bedroom
3.9 Work Space

2 Bedroom Flat
4,1 Entryway
4,2 Kitchen
4,3 Living Room
4,4 Balcony
4,5 Bathroom
4.6 Double Bedroom
4.7 Single Bedroom
4.8 Work Space

Key:

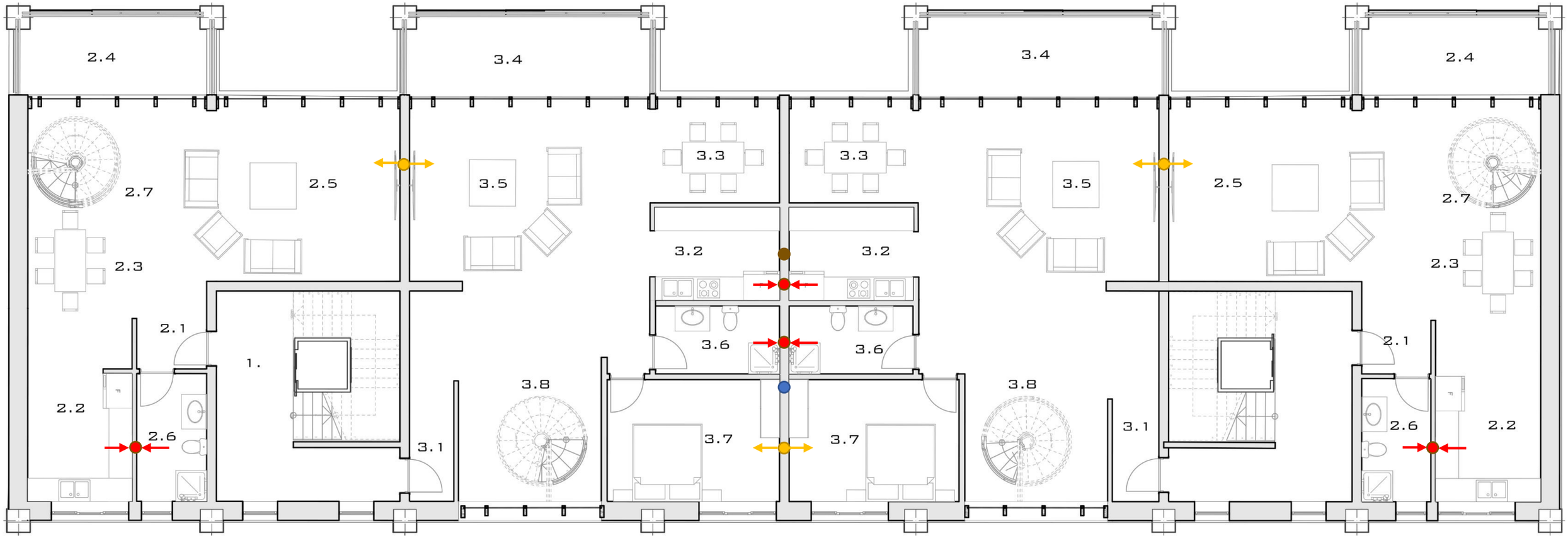
- Stuffy moist air out
- Cooled exhaust air
- Cold air from outside
- Warm fresh air in

N

Scale 1:100

0 1 2 3 4 5 6 7 8 9 10 m

Ventilation Strategy
Mechanical Ventilation
with Heat Recovery System



4TH FLOOR

KEY:

1. STAIRCASE

2 BEDROOM PENTHOUSE
2.1 ENTRYWAY
2.2 KITCHEN
2.3 DINING AREA
2.4 BALCONY
2.5 LIVING ROOM
2.6 WC
2.7 INTERNAL STAIRS

3 BEDROOM PENTHOUSE
3,1 ENTRYWAY
3,2 KITCHEN
3,3 DINING AREA
3,4 BALCONY
3,5 LIVING ROOM
3.6 WC
3.7 DOUBLE BEDROOM
3.8 INTERNAL STAIRS

Key:

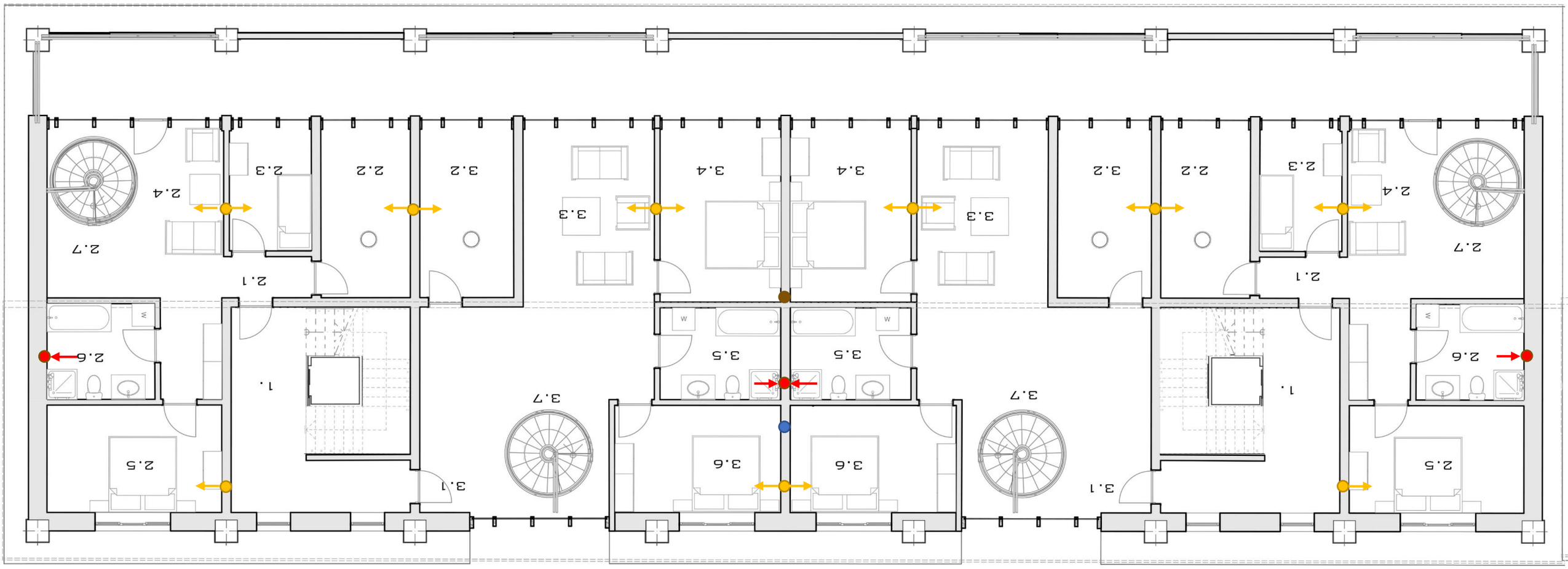
- Stuffy moist air out
- Cooled exhaust air
- Cold air from outside
- Warm fresh air in

N

SCALE 1:100

0 1 2 3 4 5 6 7 8 9 10 M

Ventilation Strategy
Mechanical Ventilation
with Heat Recovery System



5TH FLOOR

KEY:

1. STAIRCASE

2BEDROOM PENTHOUSE	3BEDROOM PENTHOUSE
2.1 ENTRYWAY	3.1 ENTRY WAY
2.2 WORK SPACE	3.2 WORK SPACE
2.3 SINGLE BEDROOM	3.3 PRIVATE LIVING ROOM
2.4 PRIVATE LIVING ROOM	3.4 DOUBLE BEDROOM
2.5 DOUBLE BEDROOM	3.5 BATHROOM
2.6 BATHROOM	3.6 DOUBLE BEDROOM
2.7 INTERNAL STAIRS	3.7 INTERNAL STAIRS

Key:

- Stuffy moist air out
- Cooled exhaust air
- Cold air from outside
- Warm fresh air in

N

SCALE 1:100

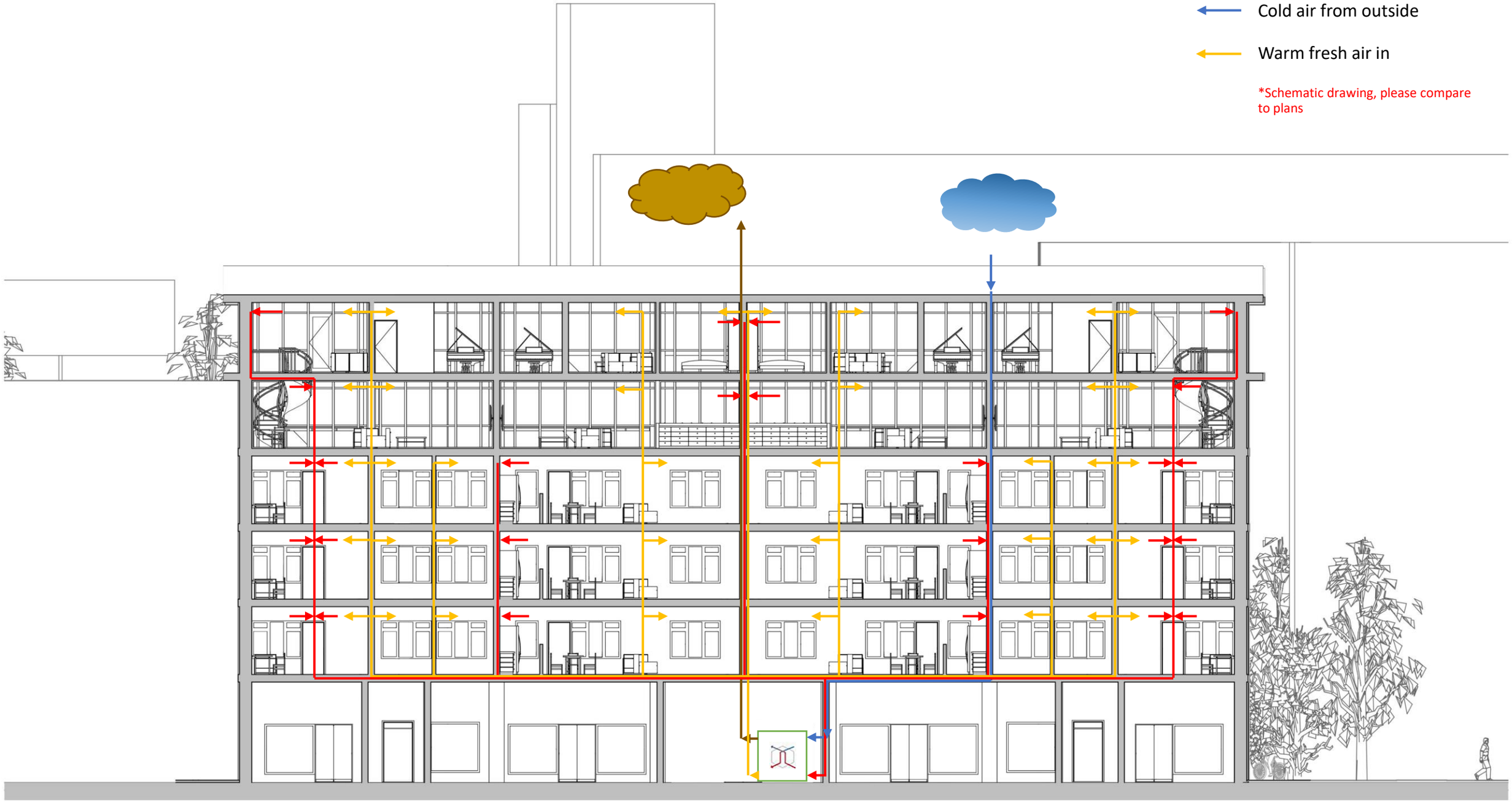
0 1 2 3 4 5 6 7 8 9 10 M

Ventilation Strategy
Mechanical Ventilation with Heat Recovery System

Key:

- Stuffy moist air out
- Cooled exhaust air
- Cold air from outside
- Warm fresh air in

*Schematic drawing, please compare to plans



SECTION A-A
(REDUCED)

SCALE 1:100

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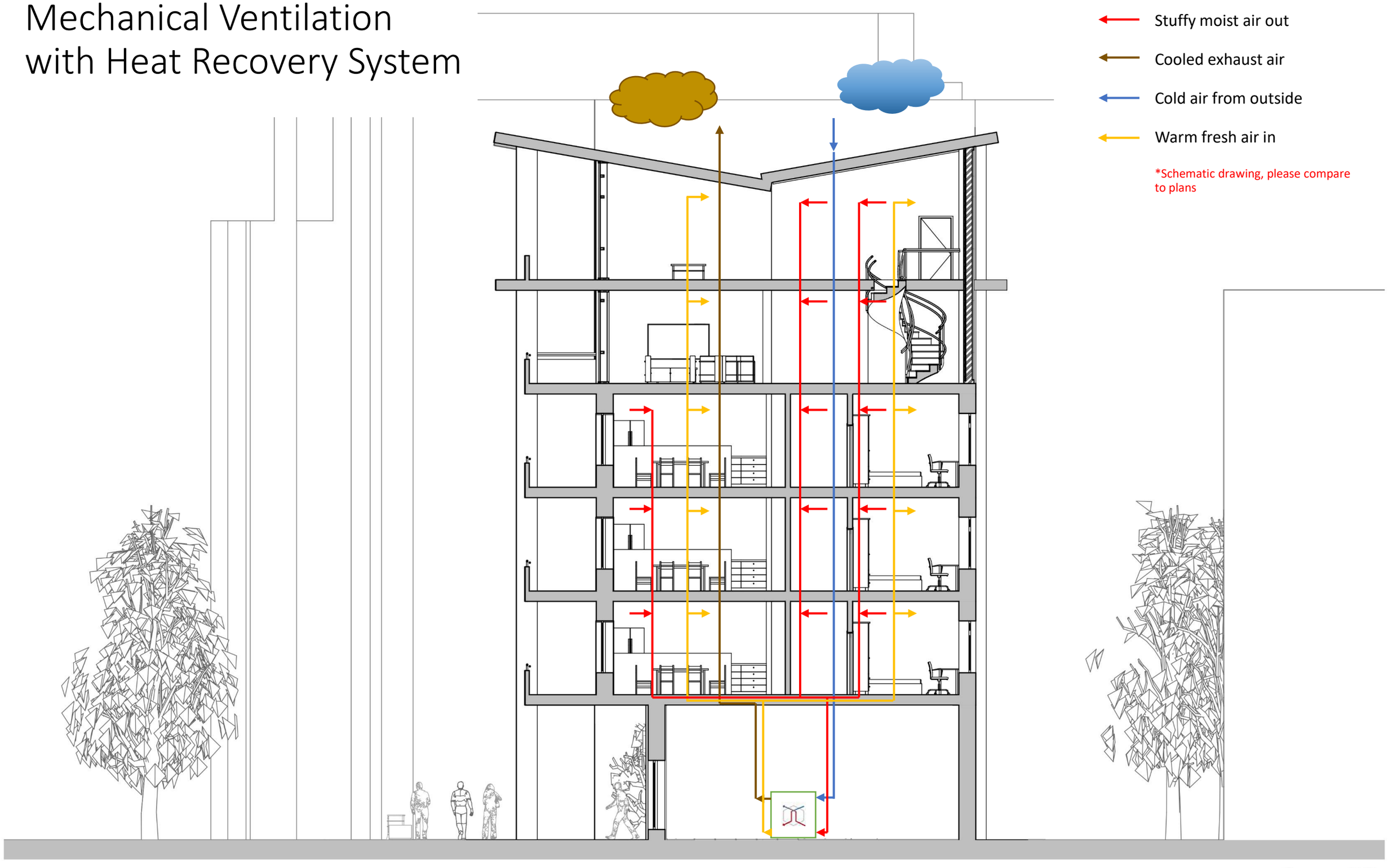
Ventilation Strategy
Mechanical Ventilation with Heat Recovery System



Section B-B