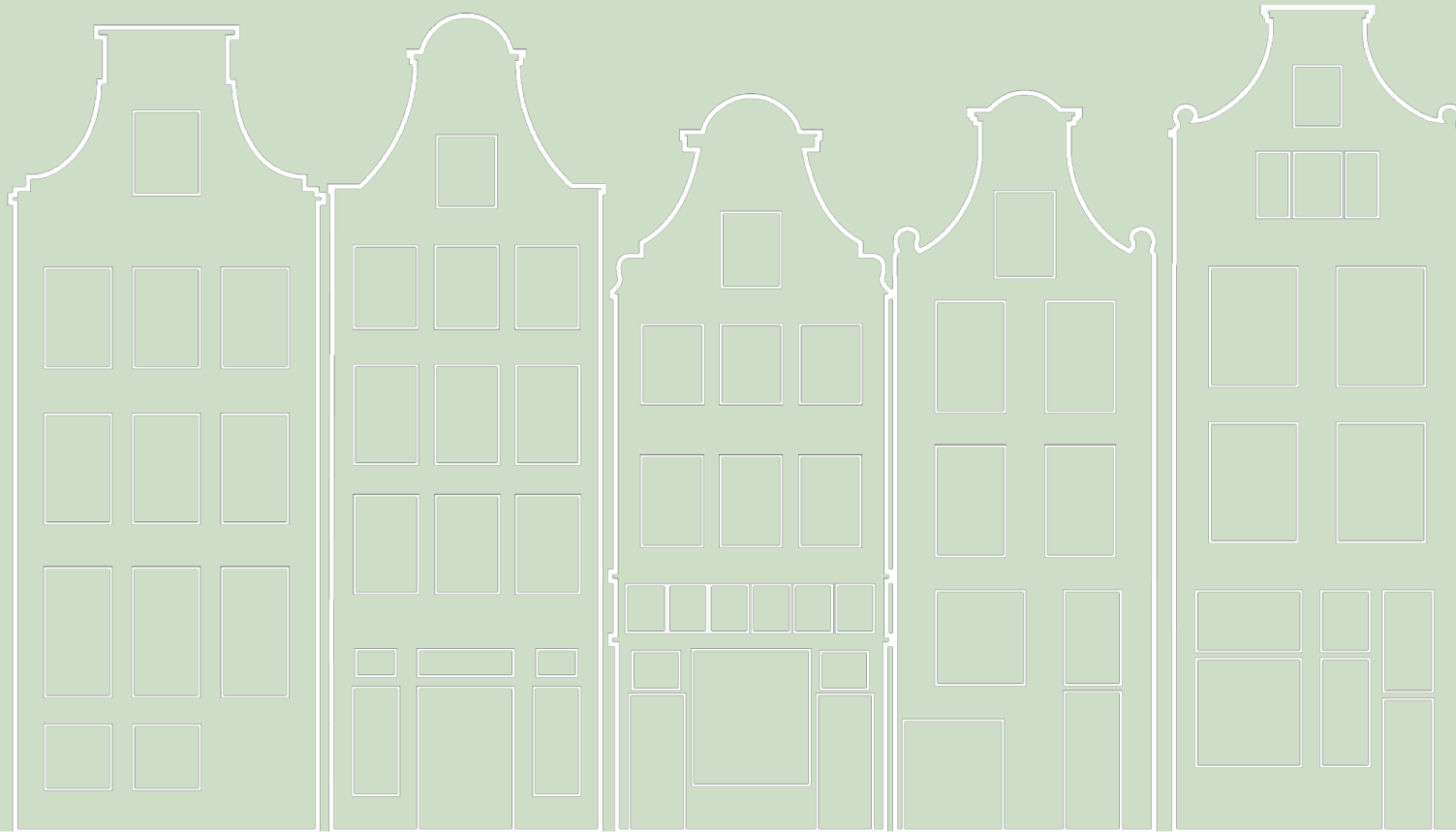


Green Light District: Energy renovation of monumental buildings



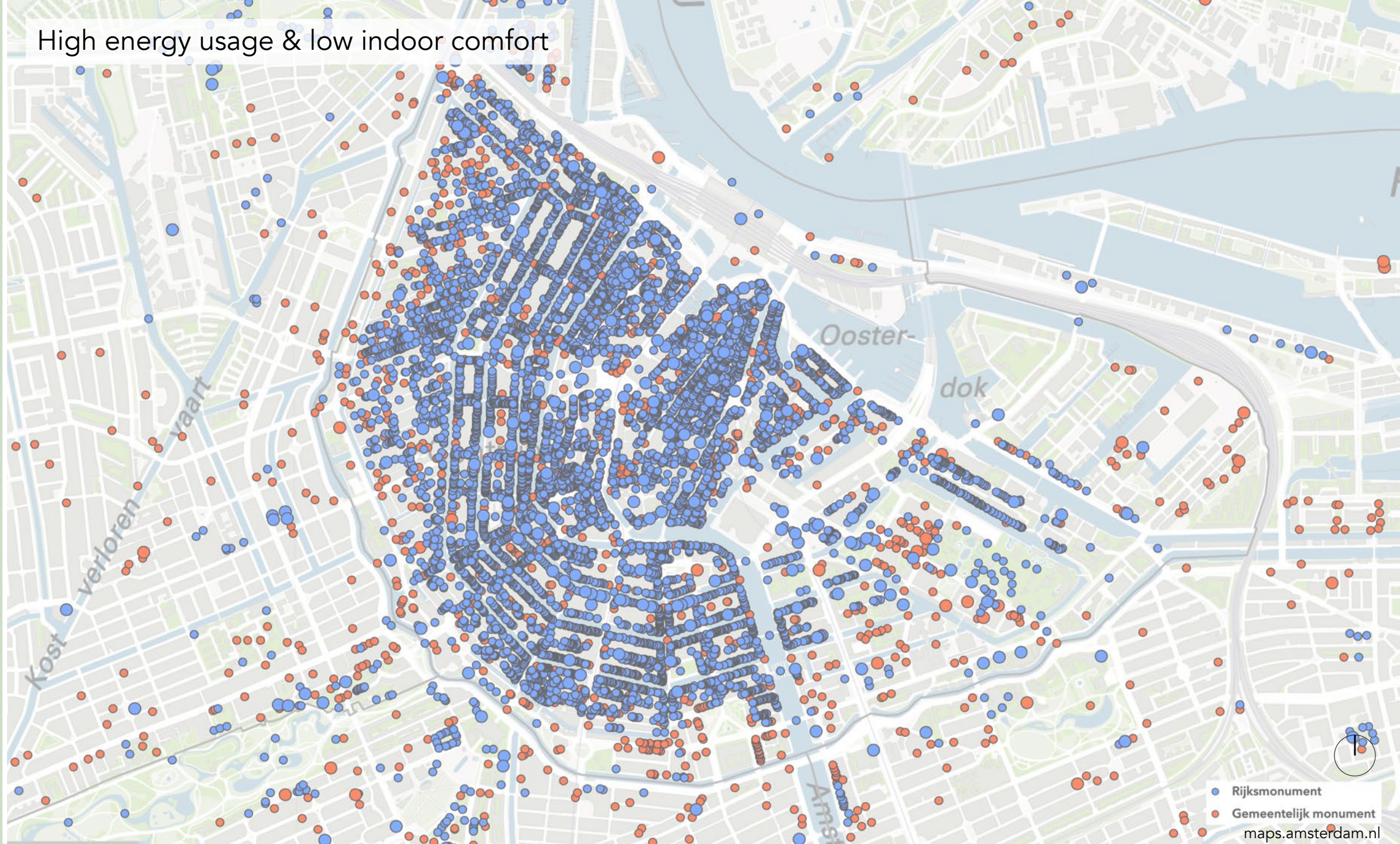
Current method of exploitation not sustainable & future proof



BACKGROUND



High energy usage & low indoor comfort

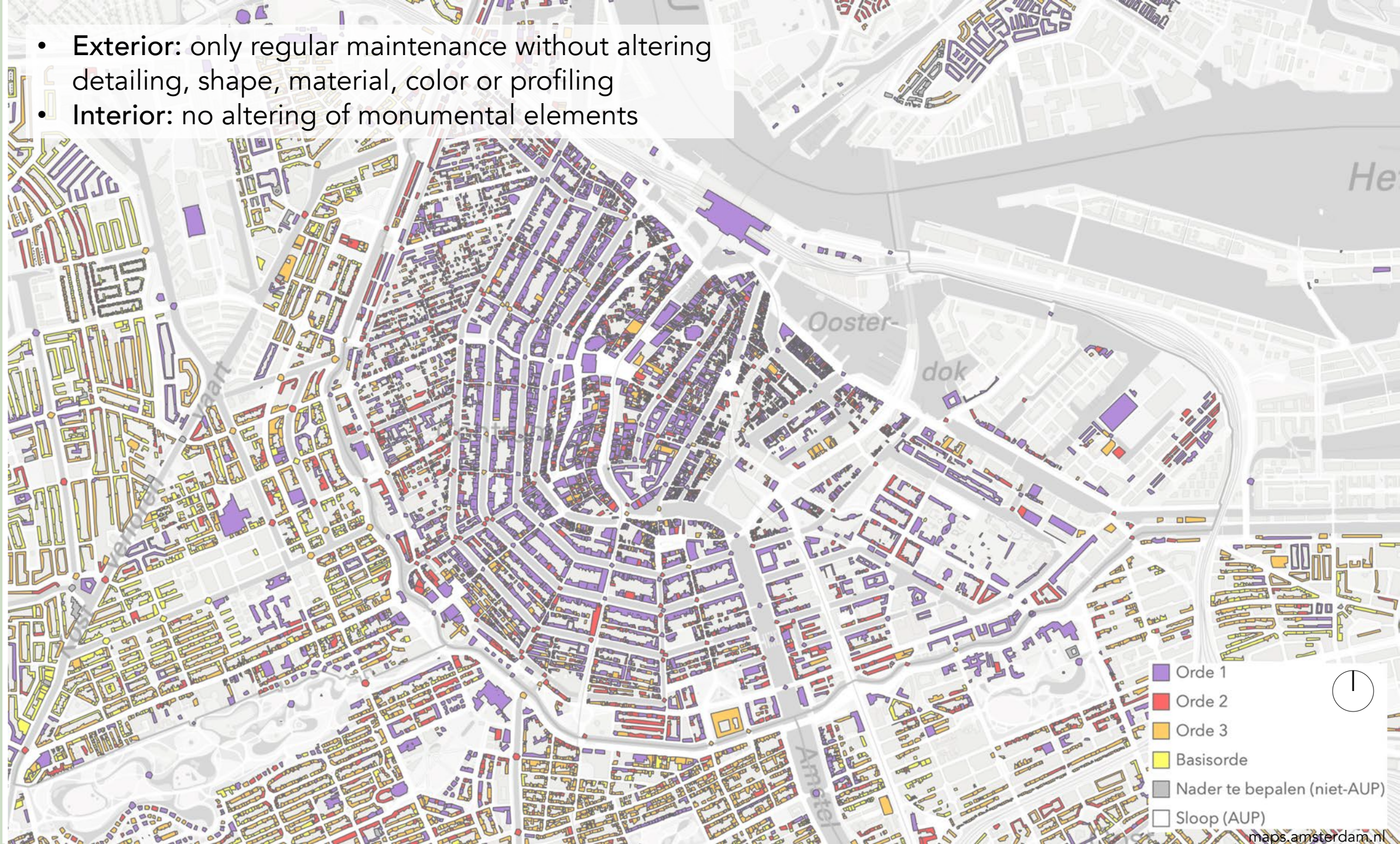




“How can monumental buildings be renovated to become energy neutral and comfortable for the users, whilst preserving the monumental status?”

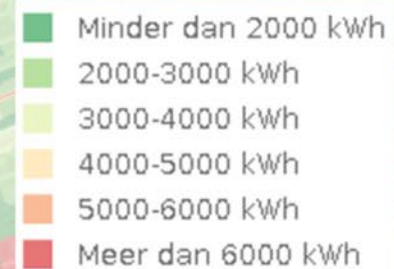


- Exterior: only regular maintenance without altering detailing, shape, material, color or profiling
- Interior: no altering of monumental elements



Energy neutral: energy usage (for construction, use & demolition) is equal to energy production on site, on a yearly basis

	Gas usage (m ³)	Electricity usage (kWh)	Total (kWh)	Total (kWh/m ²)
The Netherlands	770	1,970	9,824	151
Almere	250	2,020	4,570	80
Amsterdam	760	1,920	9,672	197
Burgwallen O-Z	980	1,930	11,926	243



Energy sources



Solar



Water

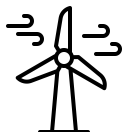


Gas

- Hydrogen
- Biogas



Air



Wind



Biomass



Rest heat



Geothermal

General measures



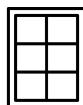
Insulation

- Exterior
- Interior



Glazing

- Double
- Triple
- Additional windowpane
- Foils



Window framing

- Wood
- Aluminum
- uPVC

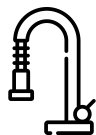


Crack sealing

- Removable
- Non-removable



Efficient appliances
or hot fill & lighting



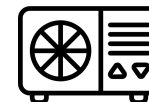
Water reduction &
heat recovery

HVAC



Boiler

- Electrical
- Gas



Heat pump

- Air - water
- Water – water
- Hybrid



Radiator

Convactor

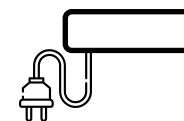


Floor heating

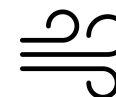


Wall heating

- 'WarmBouwen'
- TABS
- Regular wall heating



Infrared panel



Ventilation

- Mechanical
- Natural
- Combination





	Parameter	Dwellings	Retail store
Insulation (indirectly related to comfort)	Min. R-value facade ($\text{m}^2 \cdot \text{K}/\text{W}$)	4.7 (1.4 for renovation)	4.7 (1.4 for renovation)
	Min. R-value floors ($\text{m}^2 \cdot \text{K}/\text{W}$)	3.7 (2.6 for renovation)	3.7 (2.6 for renovation)
	Min. R-value roof ($\text{m}^2 \cdot \text{K}/\text{W}$)	6.1 (2.1 for renovation)	6.1 (2.1 for renovation)
	Max. U-value window ($\text{W}/\text{m}^2 \cdot \text{K}$)	2.2	2.2
Thermal	Min. T winter ($^{\circ}\text{C}$)	20	16
	Max. T summer ($^{\circ}\text{C}$)	26	25
IAQ	Min. ventilation rate (l/s per person)	7	4
	Min. RH (%)	40	40
	Max. RH (%)	70	70



OUDEZIJD'S VOORBURG WAL 30



OUDEZIJDS VOORBURG WAL 30



OUDEZIJDS VOORBURGVAL 30



Case study



OUDEZIJD'S VOORBURG WAL 30

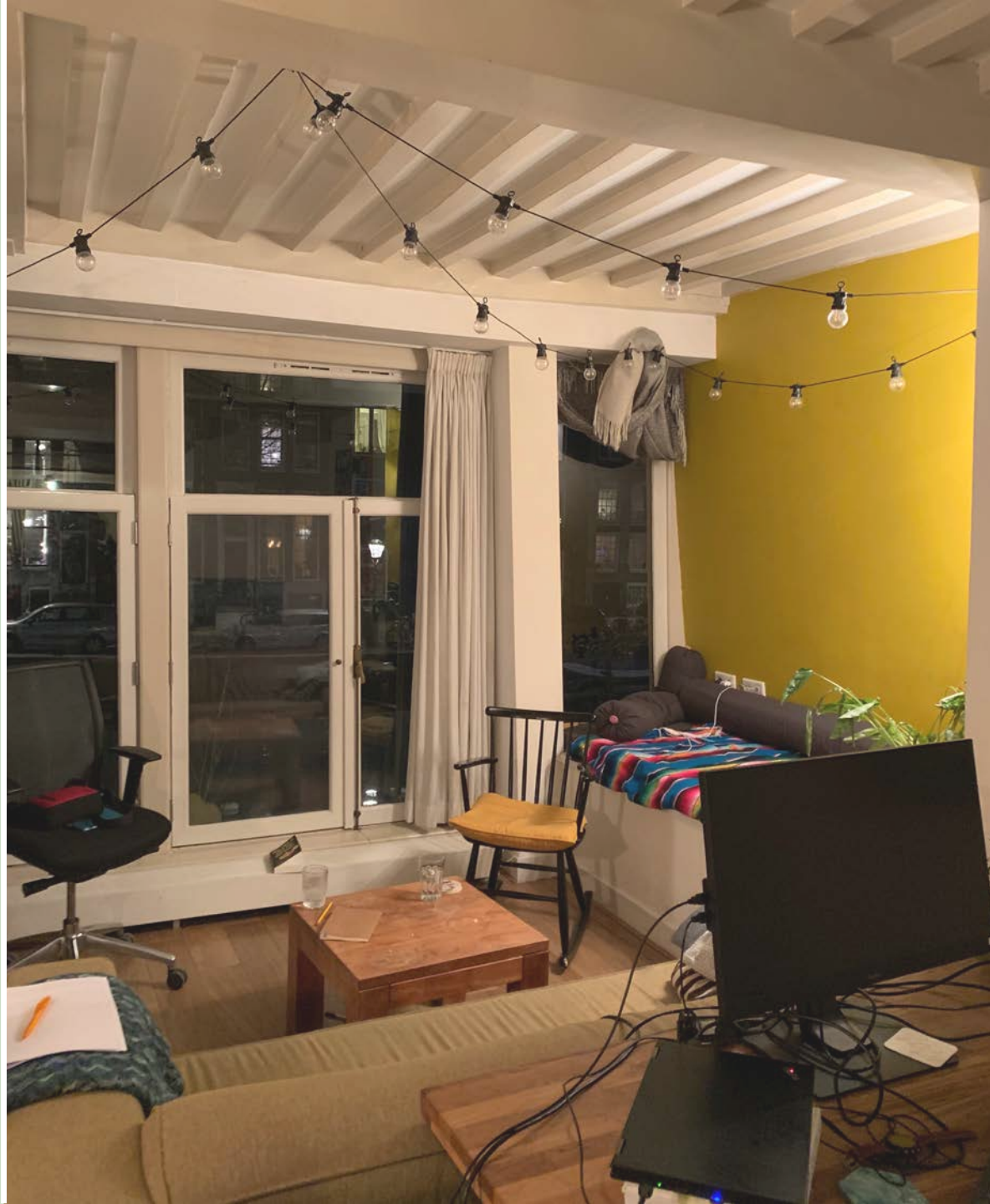
Case study

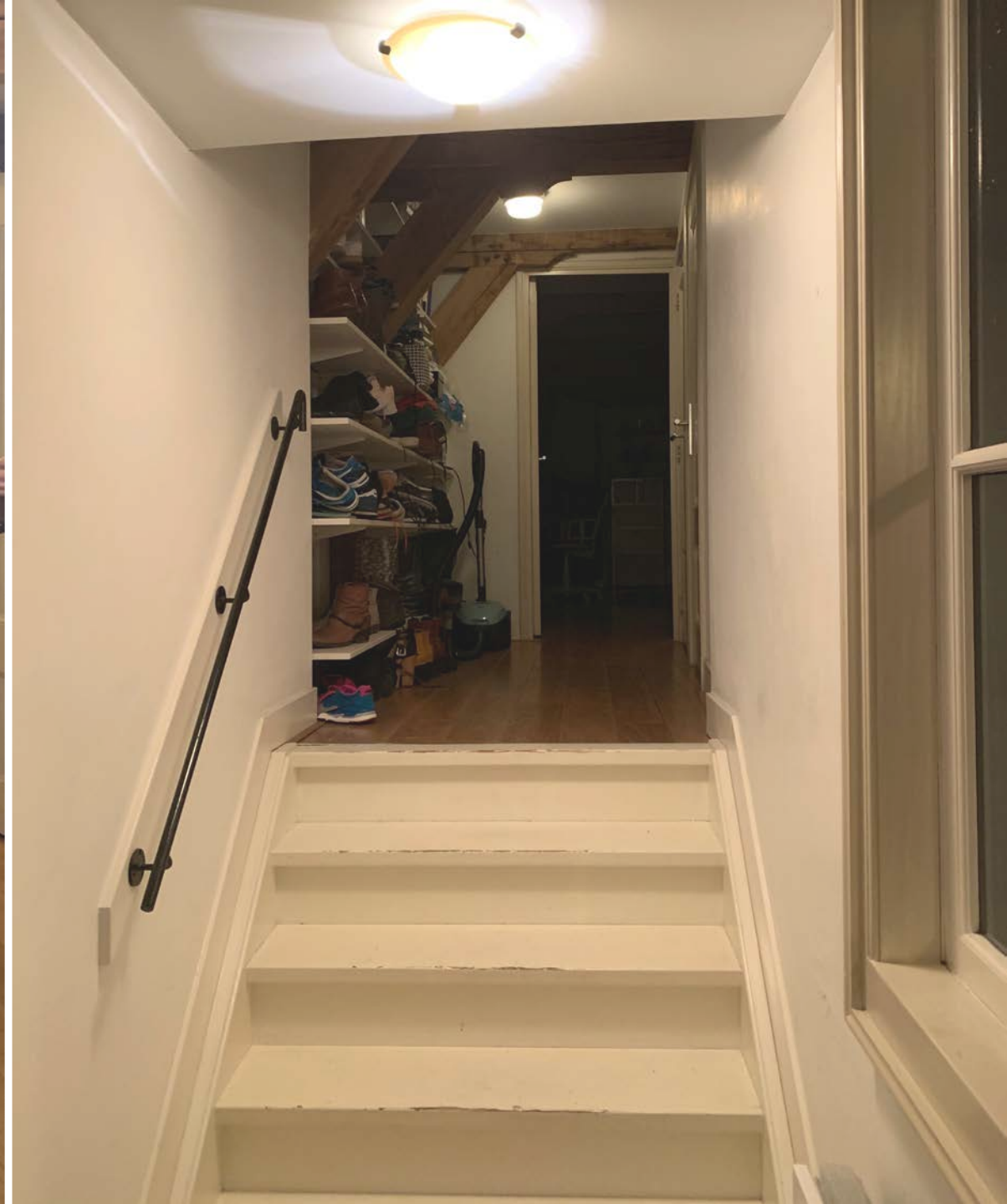


OUDEZIJD'S VOORBURG WAL 30

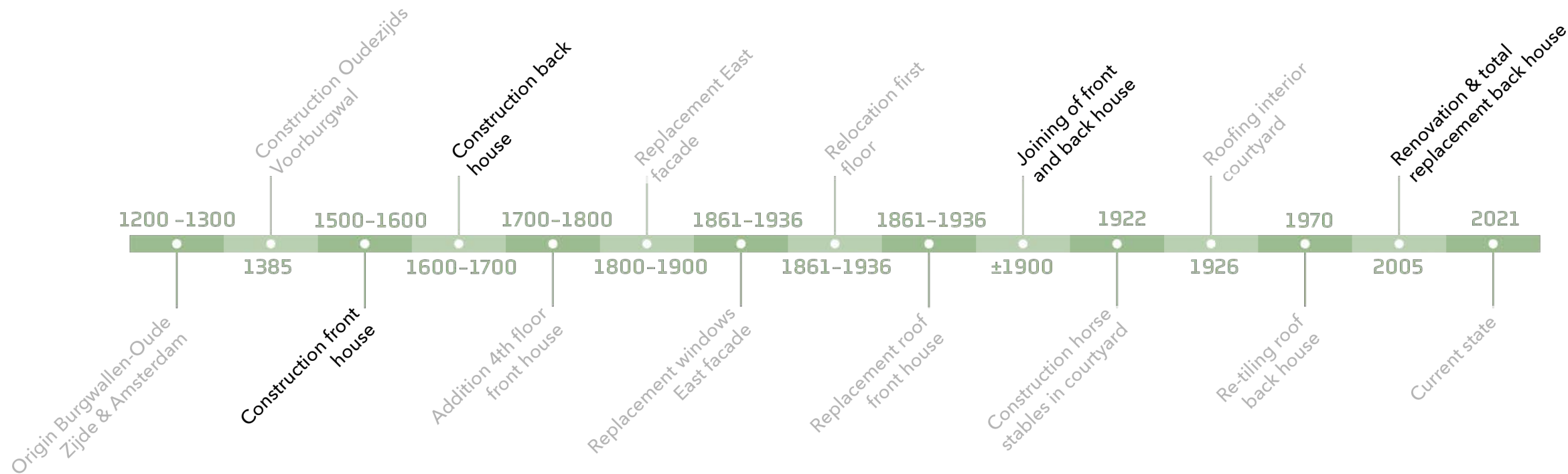






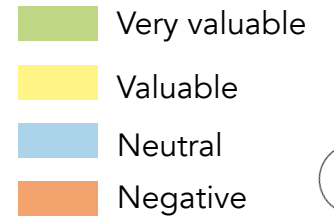


MONUMENTALITY

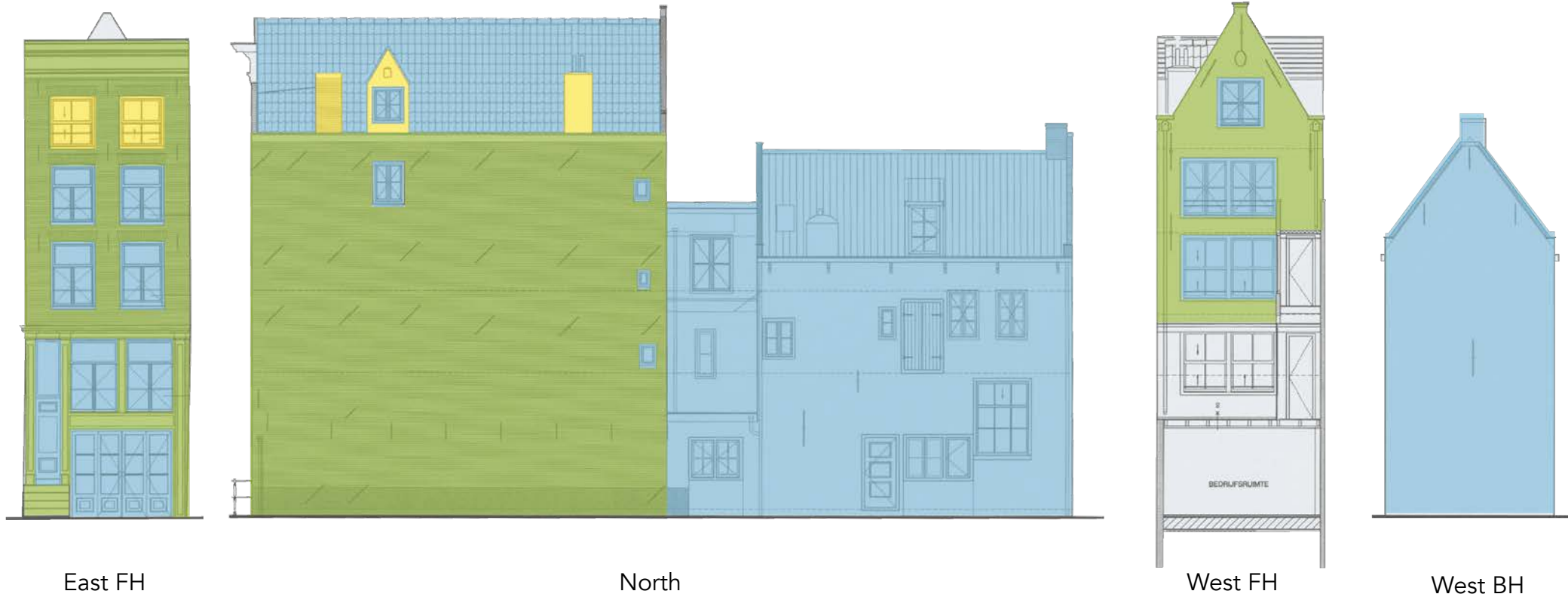




Case study



MONUMENTALITY



- Very valuable
- Valuable
- Neutral
- Negative

Case study



- Very valuable
Valuable
Neutral
Negative



MONUMENTALITY



- Very valuable
- Valuable
- Neutral
- Negative





	Period	Electricity (kWh)	Natural gas (m ³)	Natural gas (kWh)	Total (kWh)	Total (kWh/m ²)
30A	17-04-2019 to 17-04-2020	9,104.0	2,563.0	26,142.6	35,246.6	245
30B	04-09-2019 to 04-09-2020	1,669.5	785.1	8,008.0	9,677.5	118
30C	Average 2019	1,930.0	980.0	9,996.0	11,926.0	157
30D	Average 2019	1,930.0	980.0	9,996.0	11,926.0	151
Total	One year	14,633.5	5,308.1	54,142.6	68,776.1	181

ENERGY PERFORMANCE

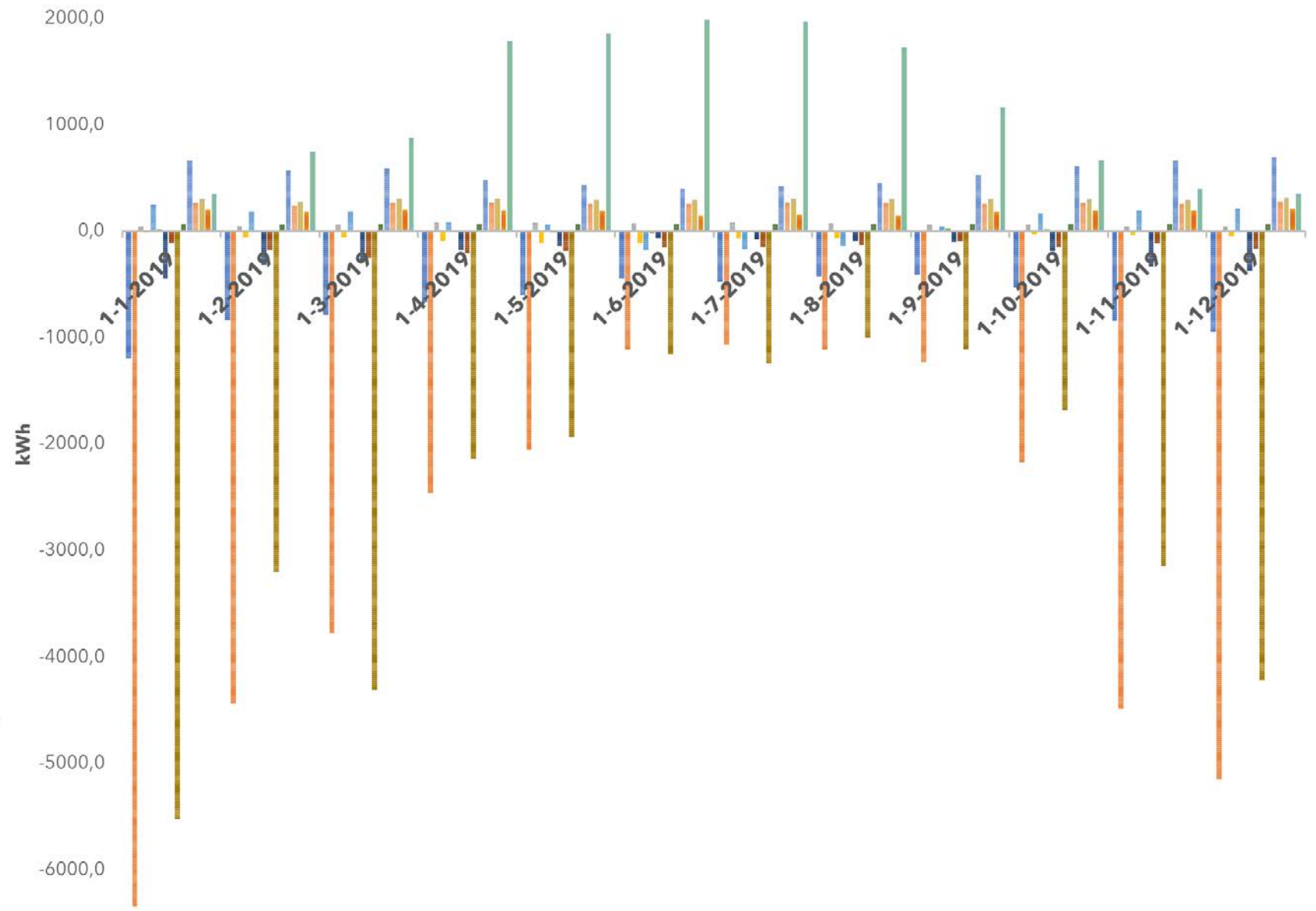




Monthly energy usage					
	Room Electricity kWh	Lighting kWh	System Pumps kWh	Heating (Gas) kWh	DHW (Gas) kWh
01-01-2019	560,4	722,5	5,3	11901,5	874,3
01-02-2019	509,9	624,2	3,0	6935,0	790,2
01-03-2019	563,3	647,8	3,3	7184,4	840,9
01-04-2019	565,4	545,5	1,1	2505,2	830,9
01-05-2019	546,4	495,1	0,8	1806,9	762,8
01-06-2019	545,5	455,8	0,1	91,4	698,9
01-07-2019	574,8	486,8	0,1	33,8	721,1
01-08-2019	554,8	516,4	0,1	5,9	673,8
01-09-2019	551,4	589,0	0,2	351,5	680,9
01-10-2019	560,4	674,1	1,1	2335,1	749,7
01-11-2019	545,5	717,3	3,0	6995,8	747,8
01-12-2019	583,2	760,7	3,9	8998,6	856,7
Total energy usage (kWh)					
2019	6661,0	7235,2	22,1	49145,1	9228,1
Total energy usage yearly (kWh)					
Total elec usage	13918,4				
Total gas usage	58373,3				
Total energy usage	72291,6				

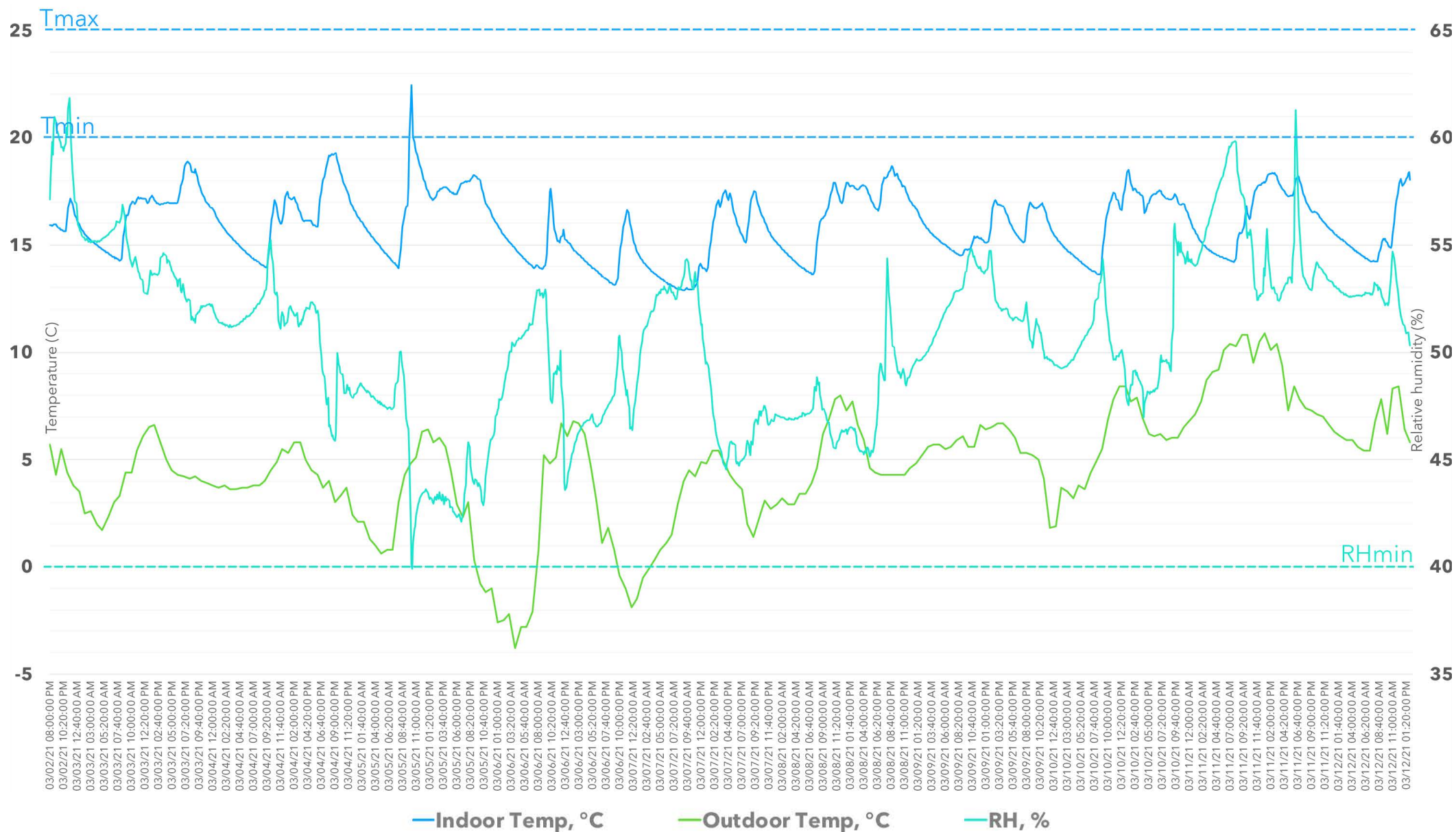
ENERGY PERFORMANCE

- Glazing kWh
- Floors (int) kWh
- Roofs kWh
- Task Lighting kWh
- Computer + Equip kWh
- Walls kWh
- Ground Floors kWh
- Internal Natural vent. kWh
- General Lighting kWh
- Occupancy kWh
- Ceilings (int) kWh
- Partitions (int) kWh
- External Infiltration kWh
- Miscellaneous kWh
- Solar Gains Exterior Windows kWh





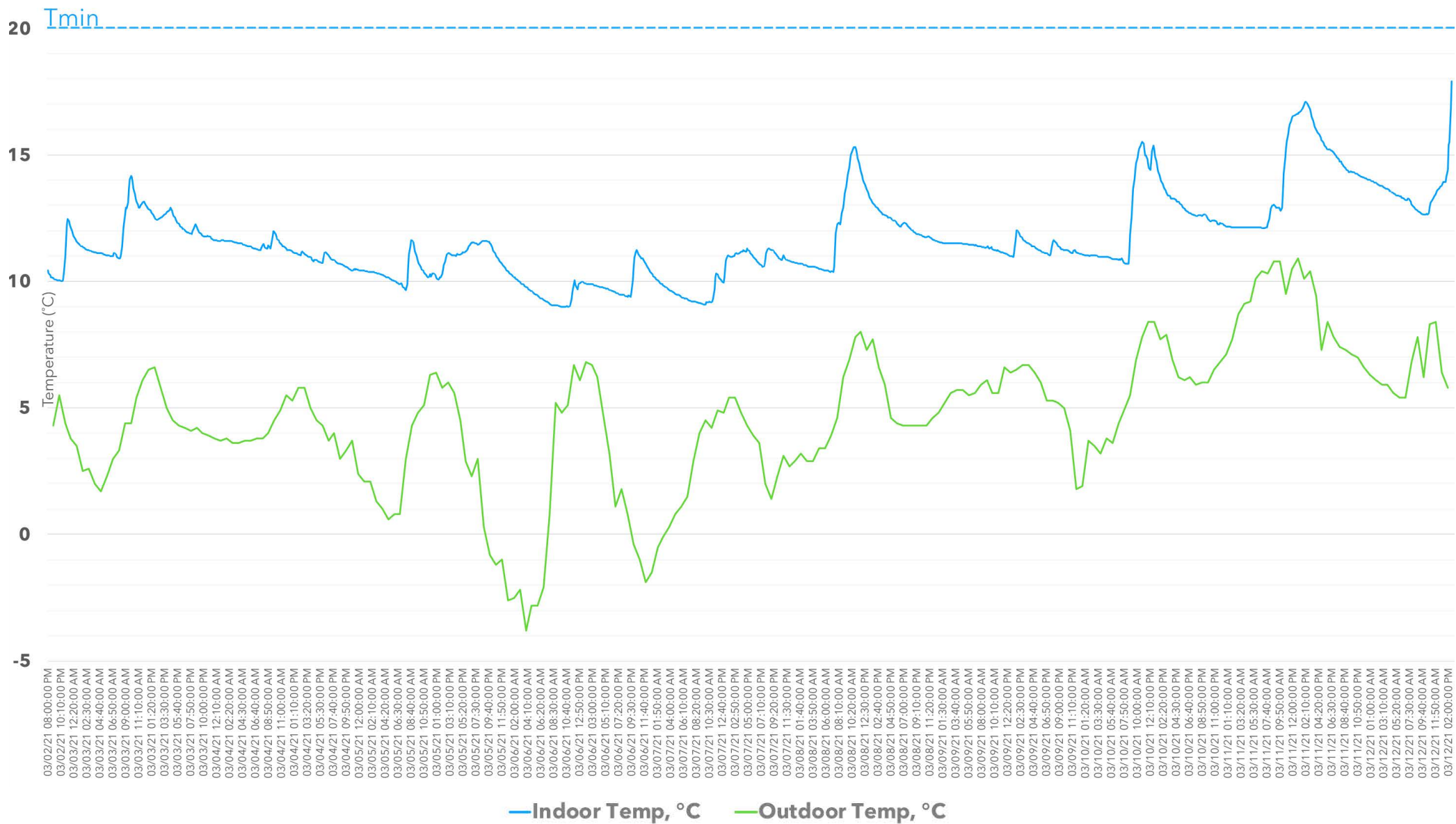
INDOOR COMFORT



Front house



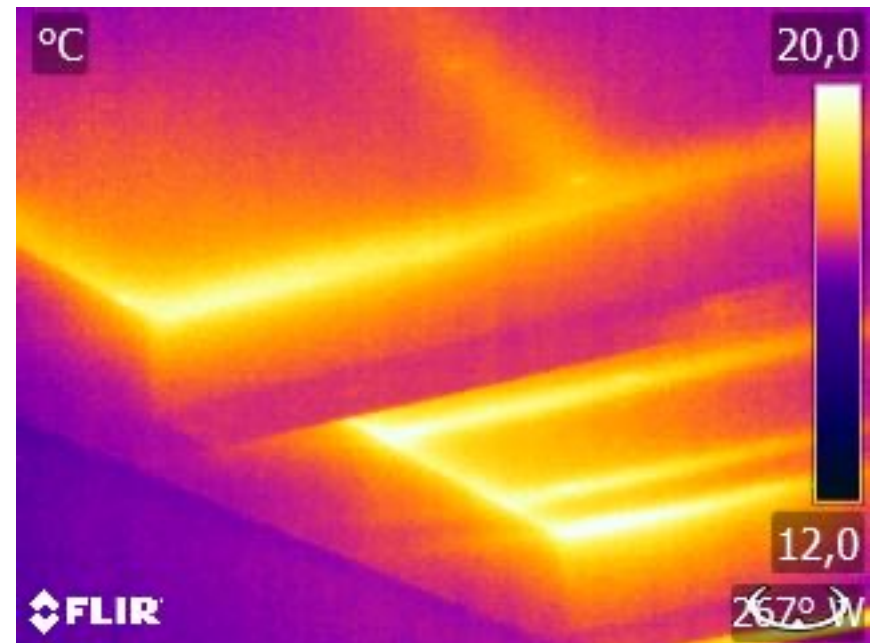
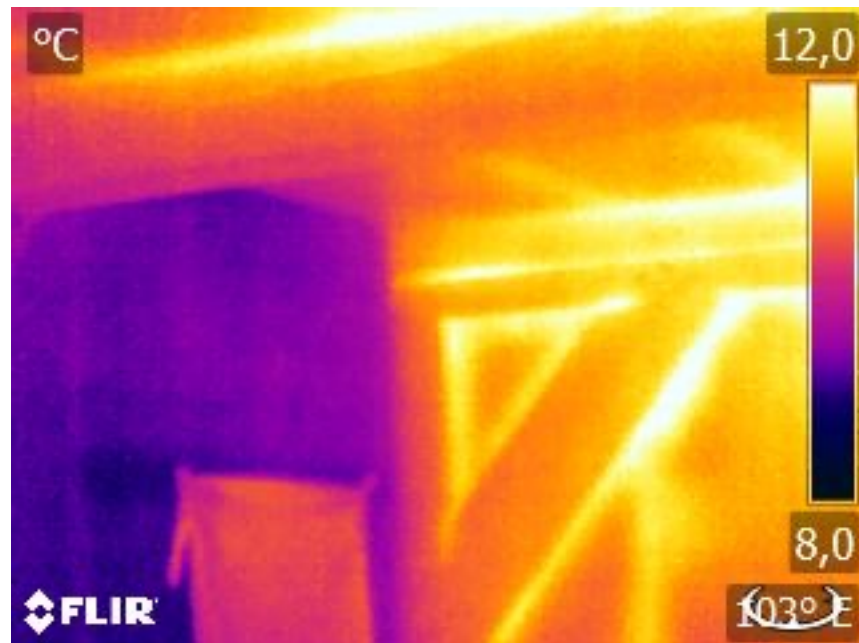
INDOOR COMFORT



Back house

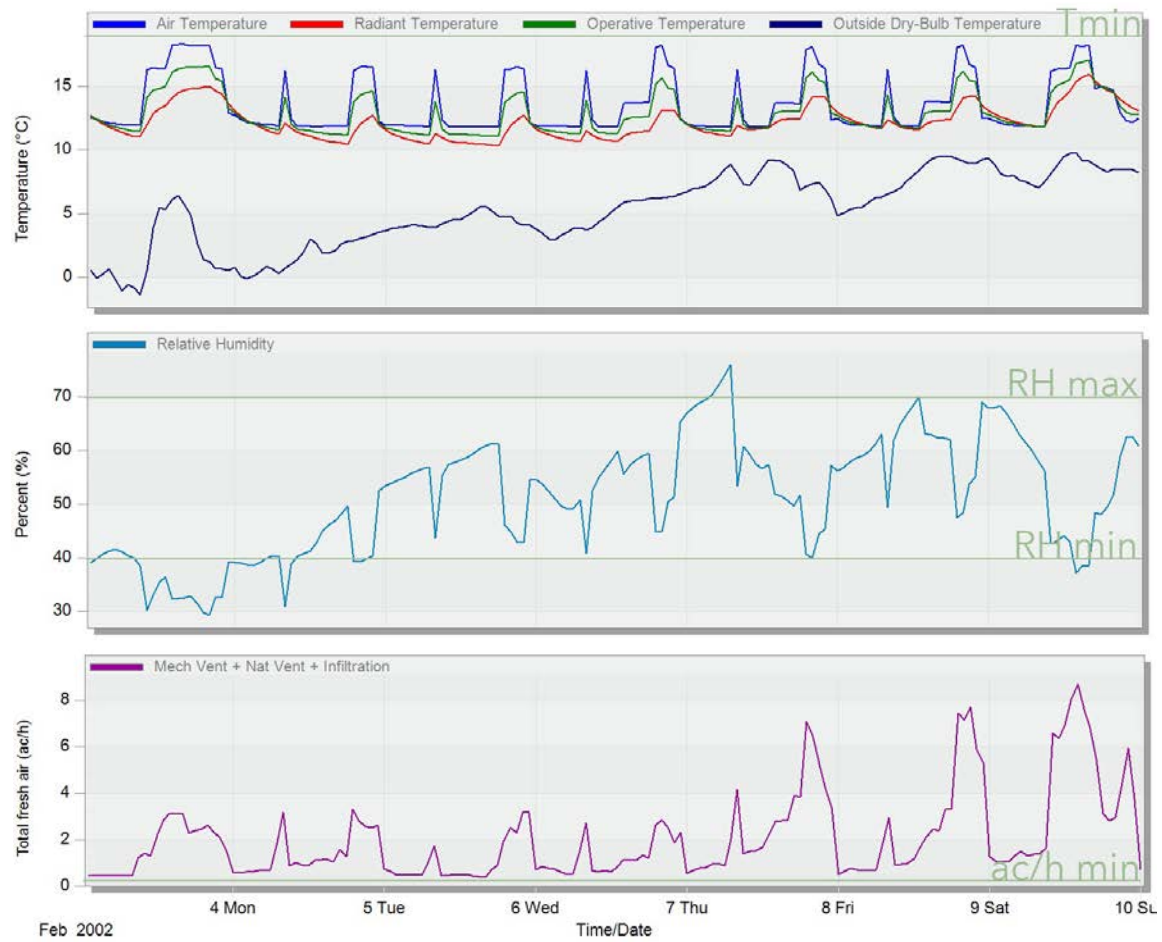


INDOOR COMFORT

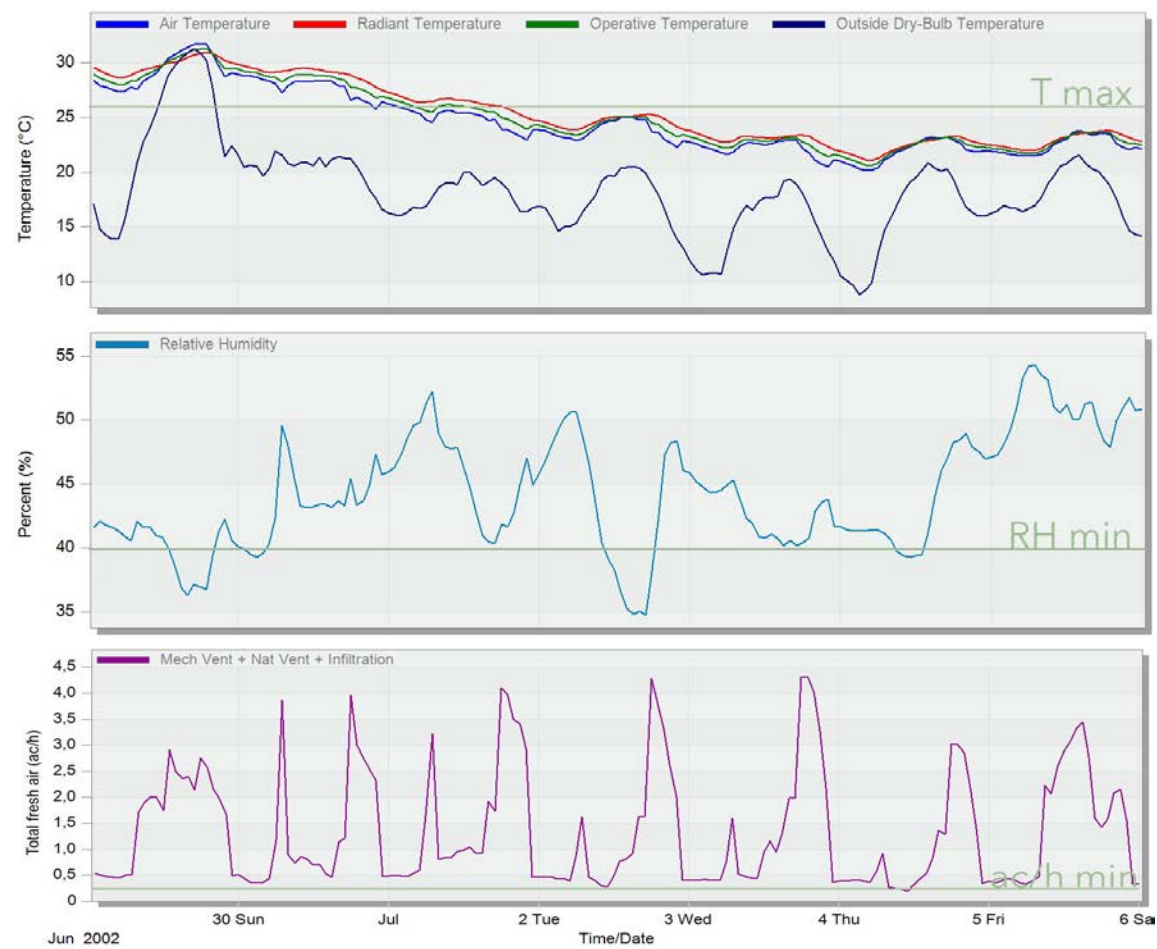




INDOOR COMFORT



Winter



Summer





Monumentality

- Back house: alterations possible to exterior & interior
- Front house: alterations to exterior & interior restricted



Energy performance

- Average performance compared to neighborhood
- Low performance compared to NL

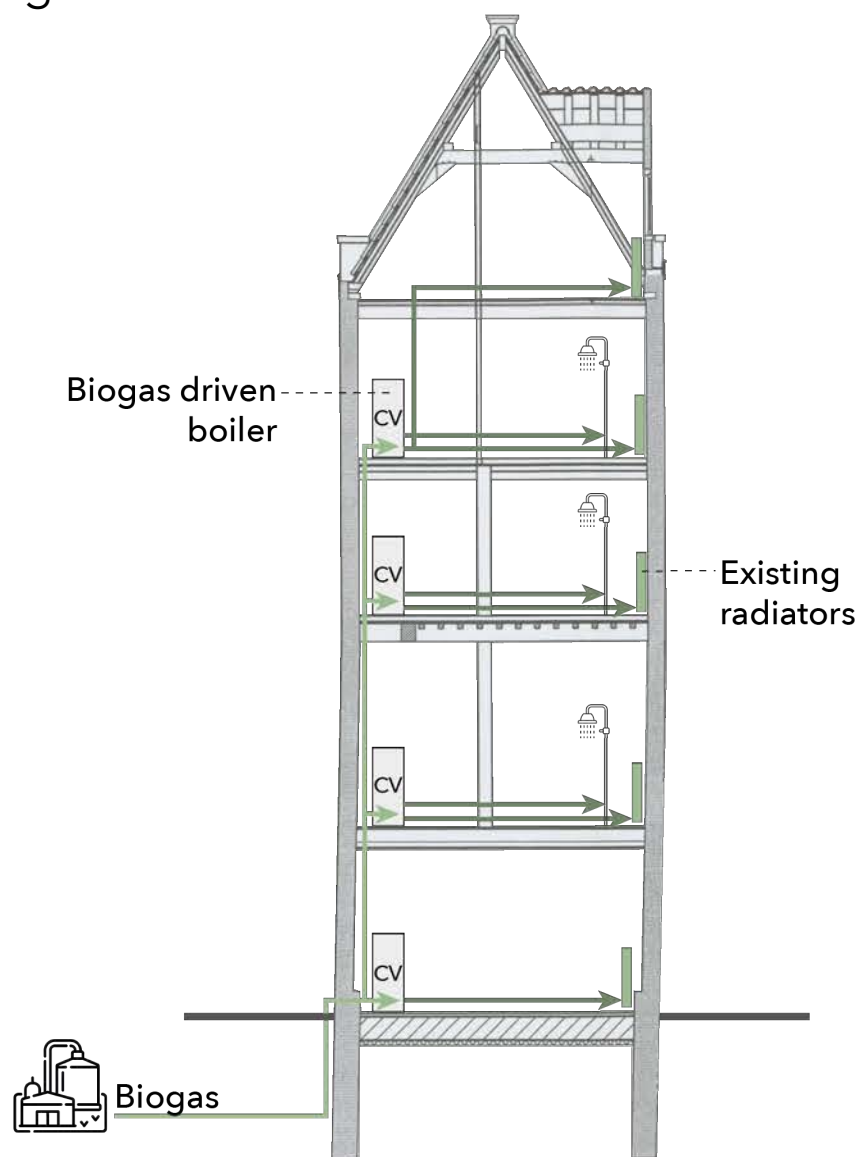


Indoor comfort

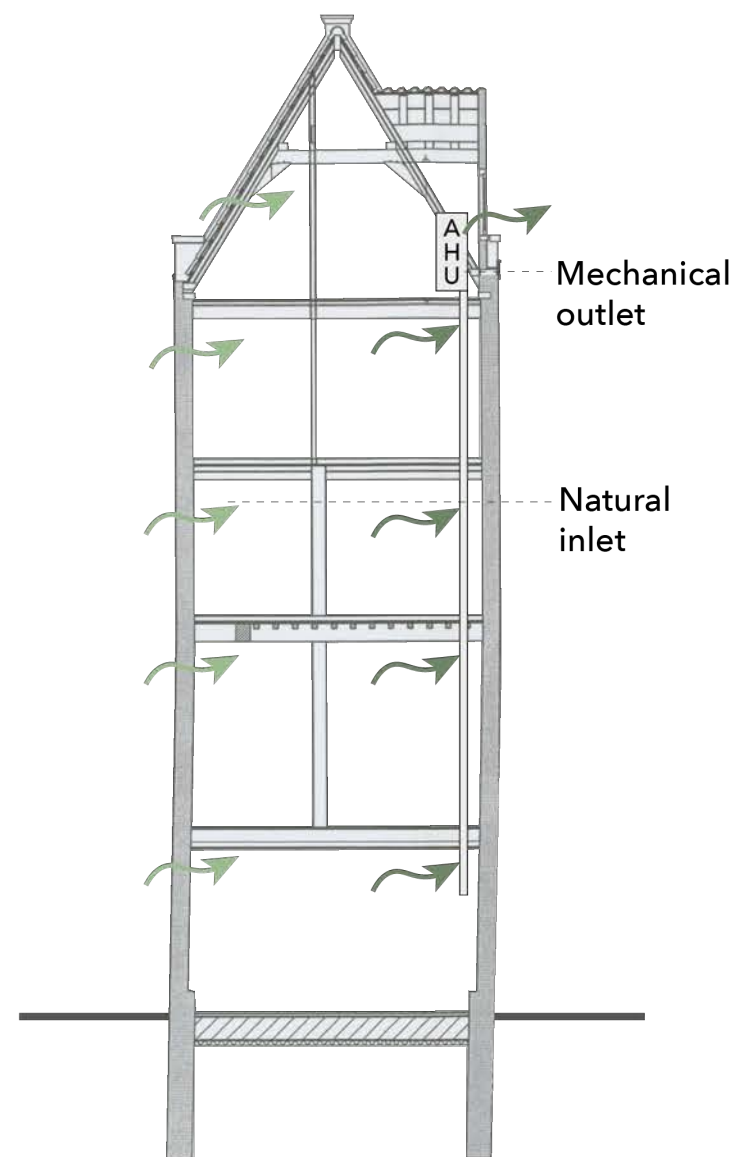
- Does not adhere to any of set criteria
- Discomfort perceived



Concept 1: Biogas



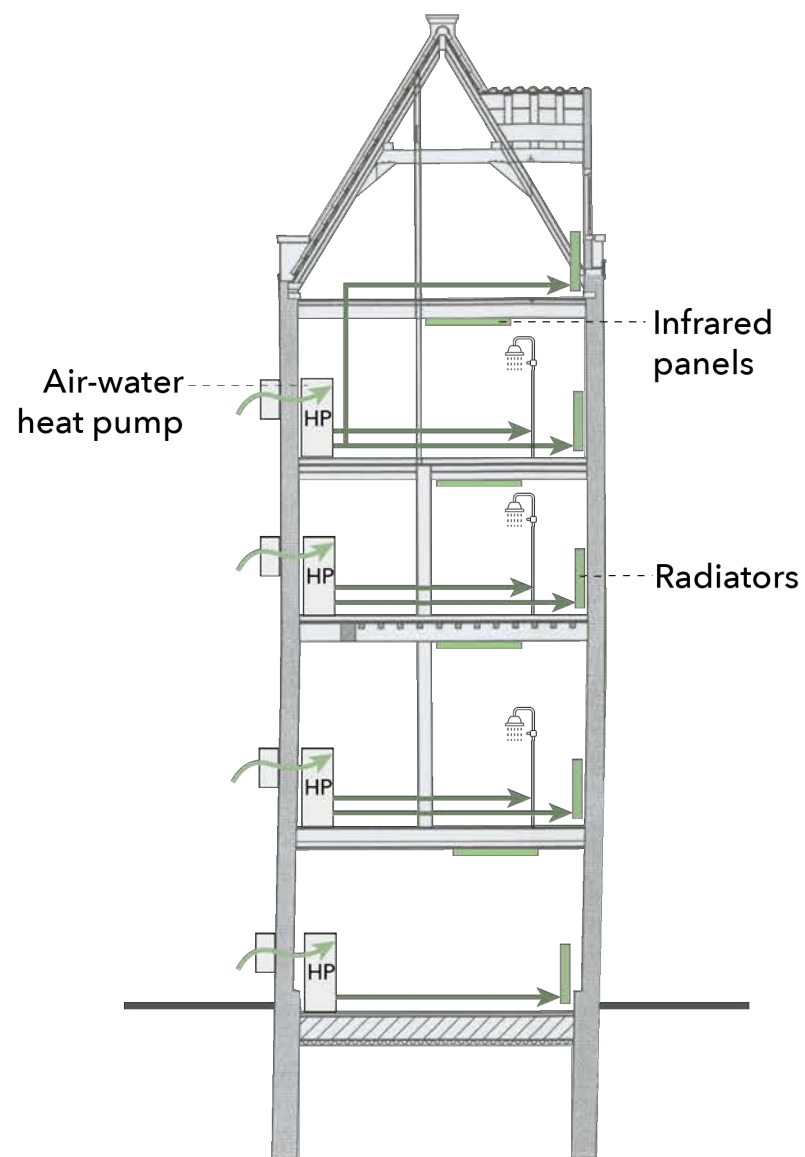
Heating



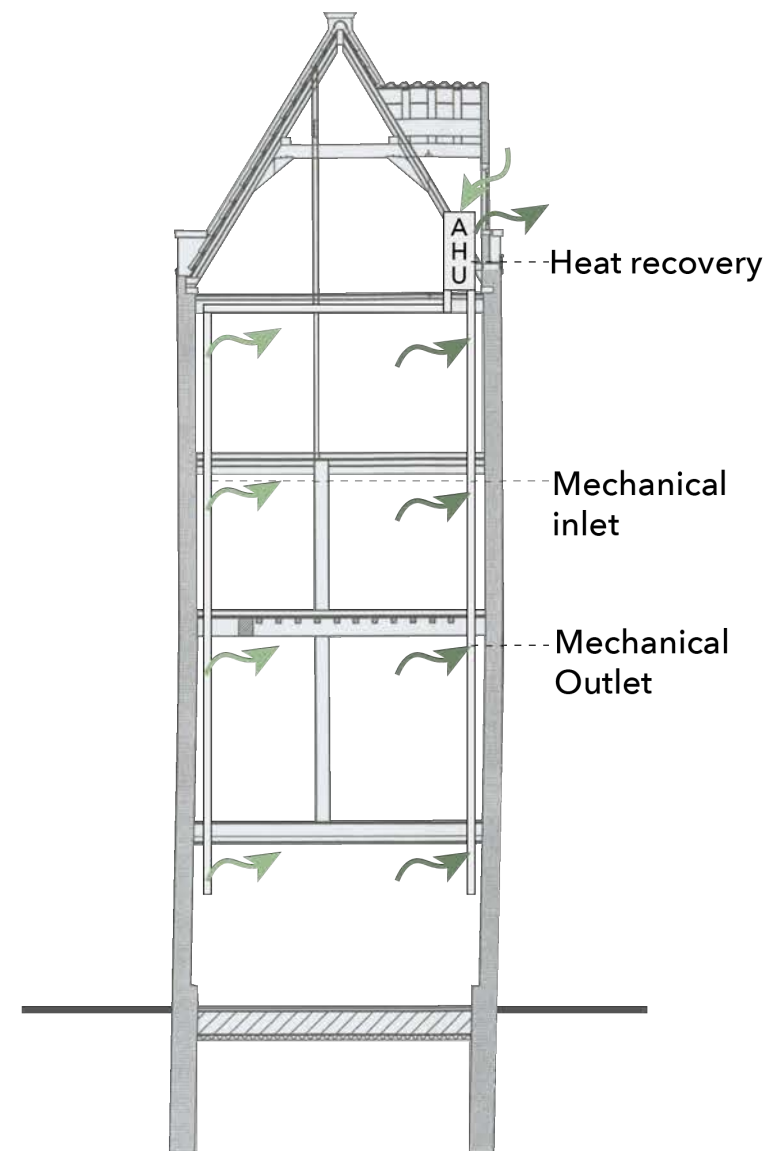
Ventilation



Concept 2: All-electric



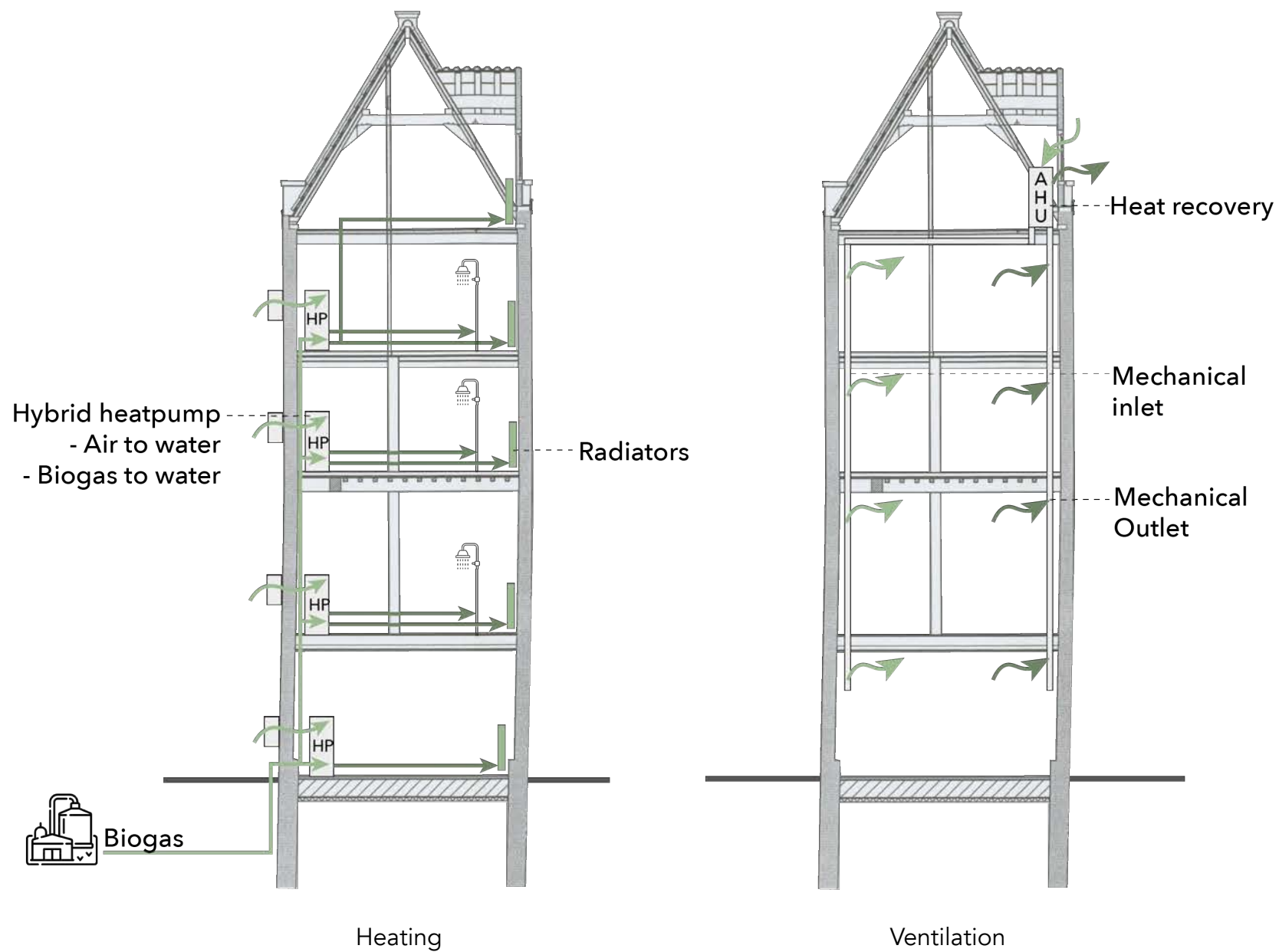
Heating



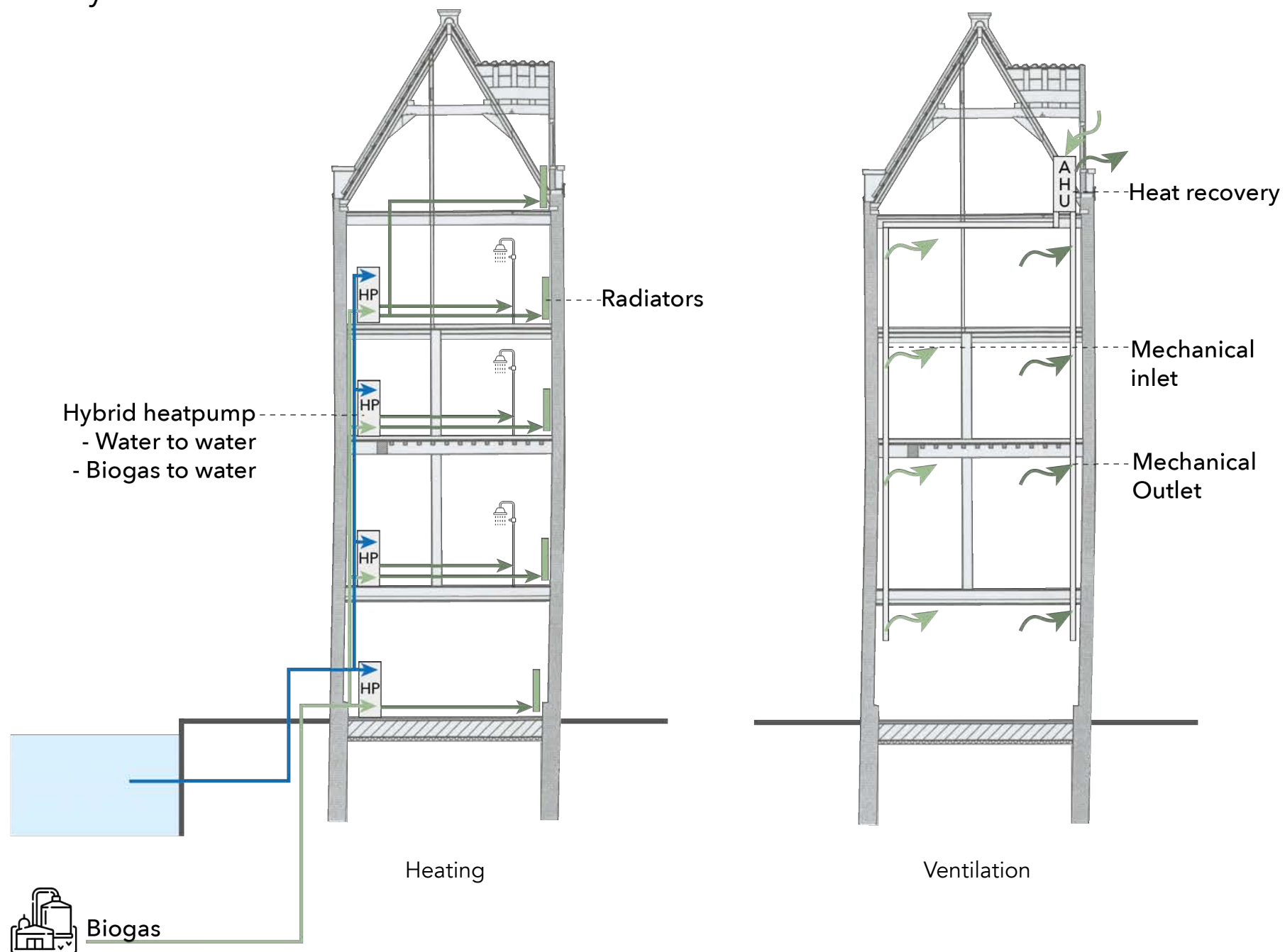
Ventilation



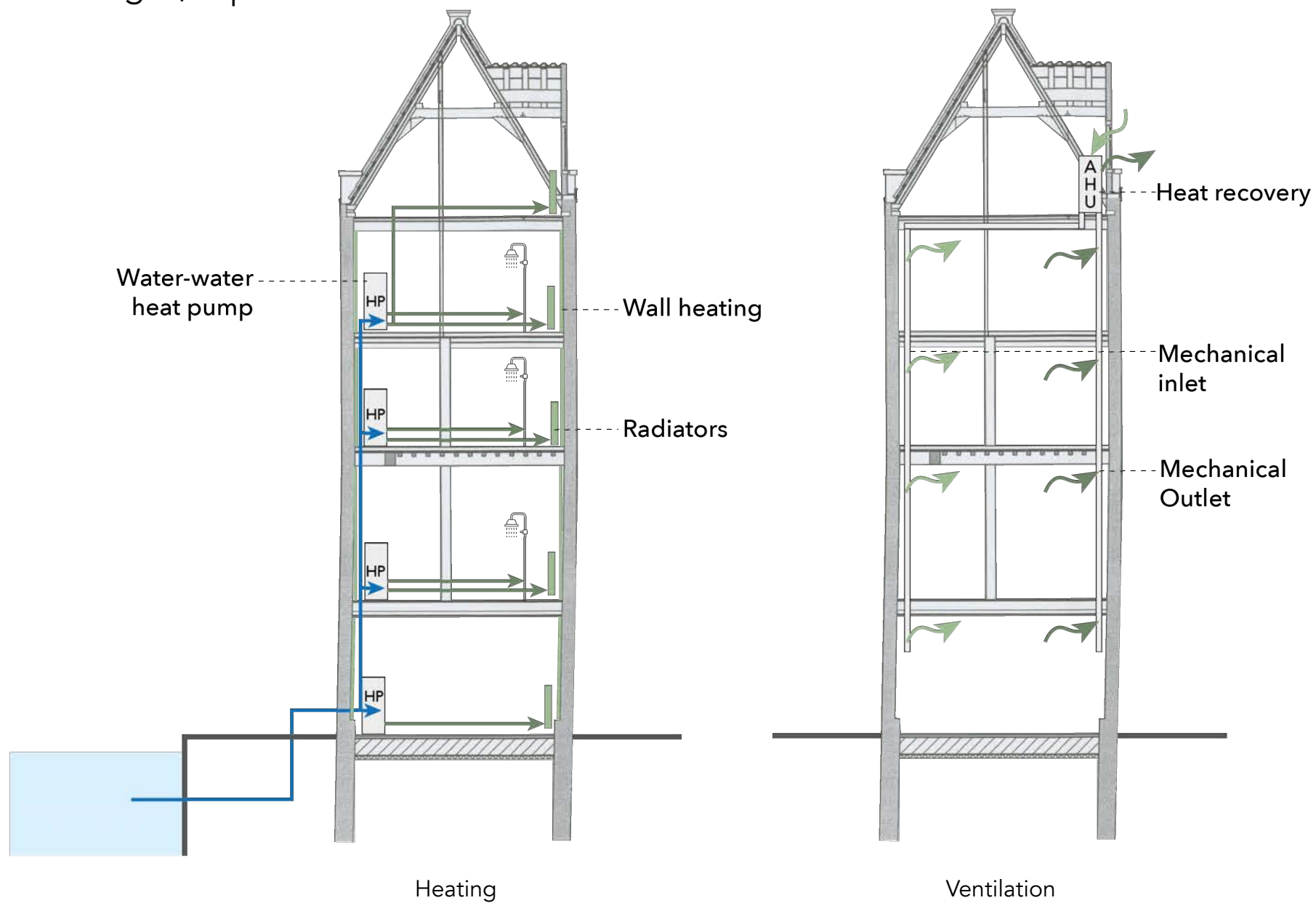
Concept 3: Hybrid not near water



Concept 4: Hybrid near water

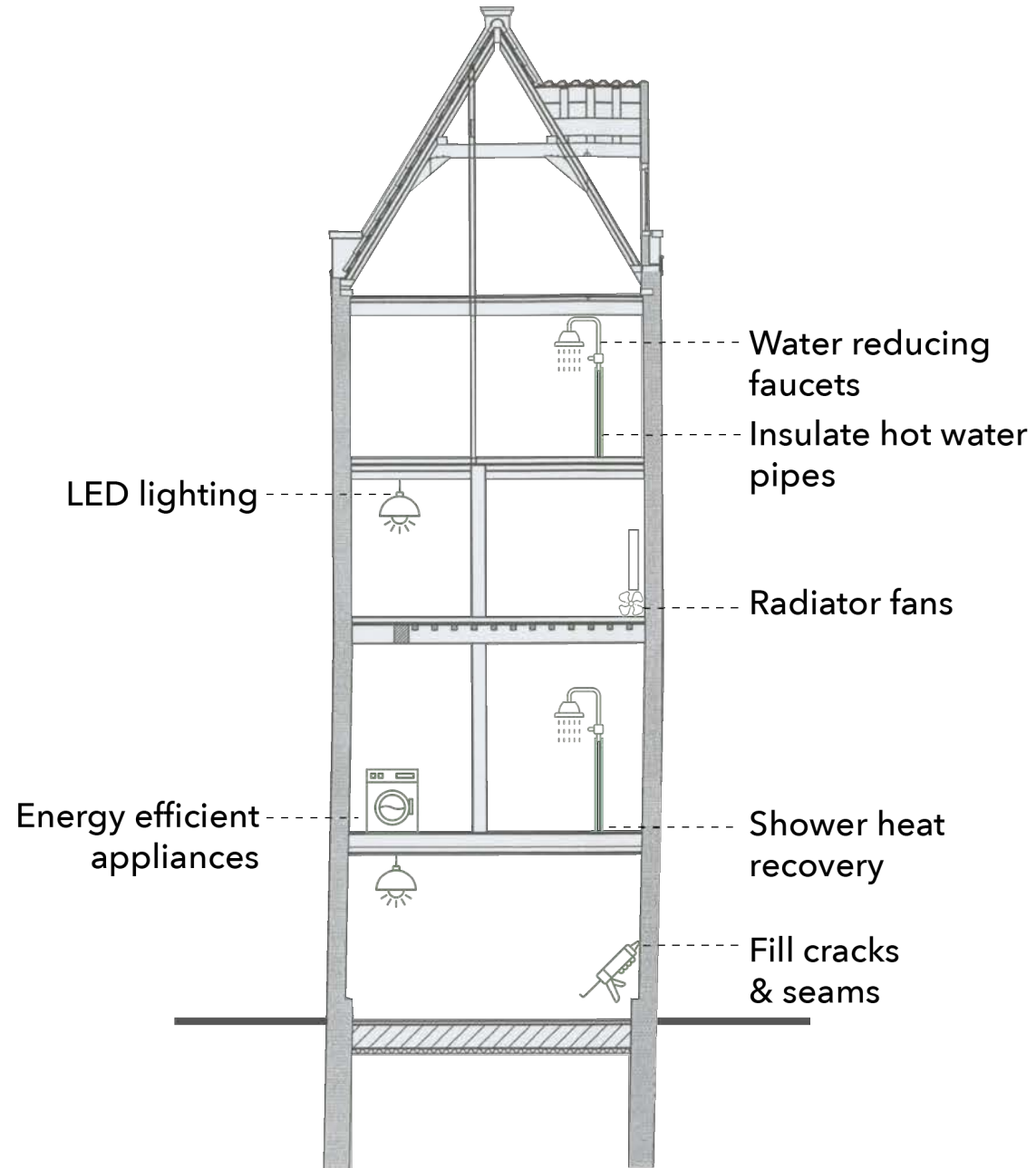


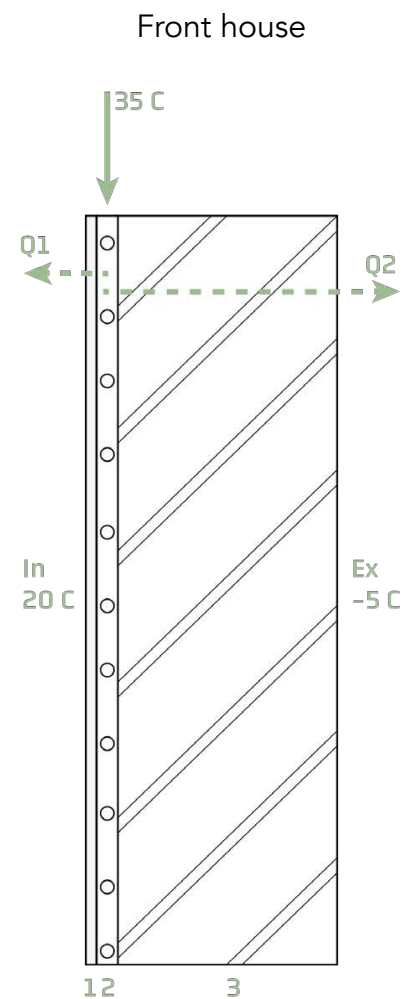
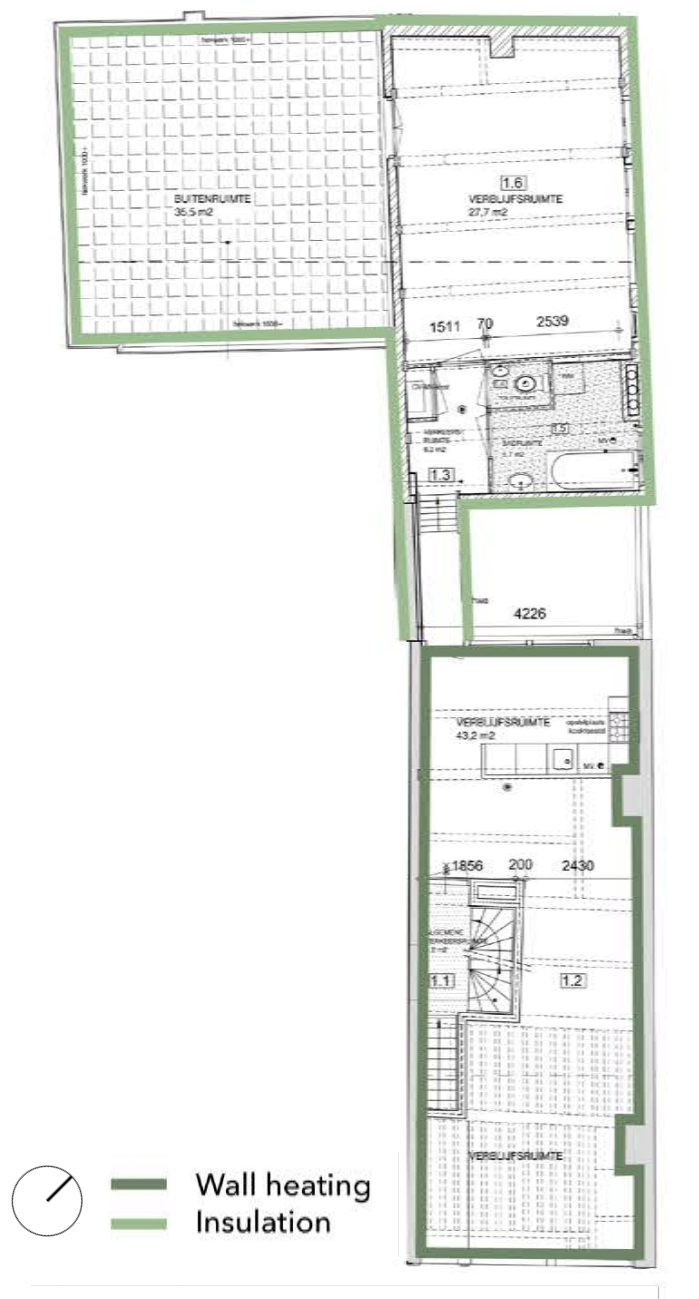
Concept 5: Off gas, aquathermal



	Concept 1: Biogas	Concept 2: All-electric	Concept 3: Hybrid not near water	Concept 4: Hybrid near water	Concept 5: Off gass, aquathermal
Surrounding potential	--	-	-	+	++
Sustainability	--	++	0	0	++
Energy performance	-	++	+	+	++
Indoor comfort	+	?	+	+	?
Monumentality	++	-	-	+	+
Technical	++	0	0	-	0
Aesthetical	+	-	0	+	+
New materials	+	--	-	-	-
Financial	++	0	+	--	--

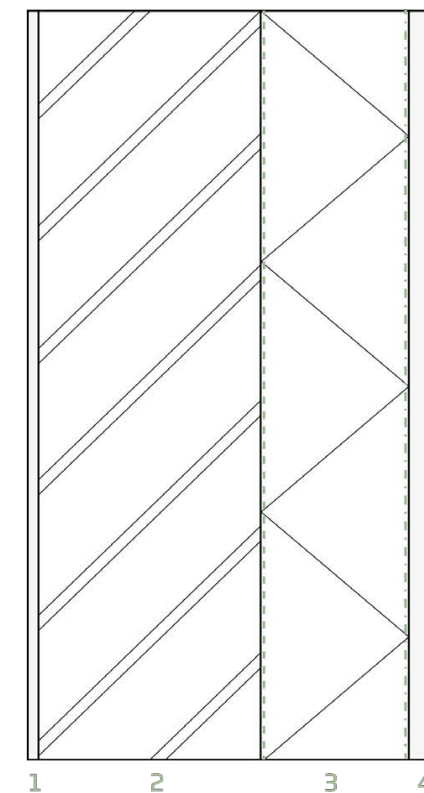




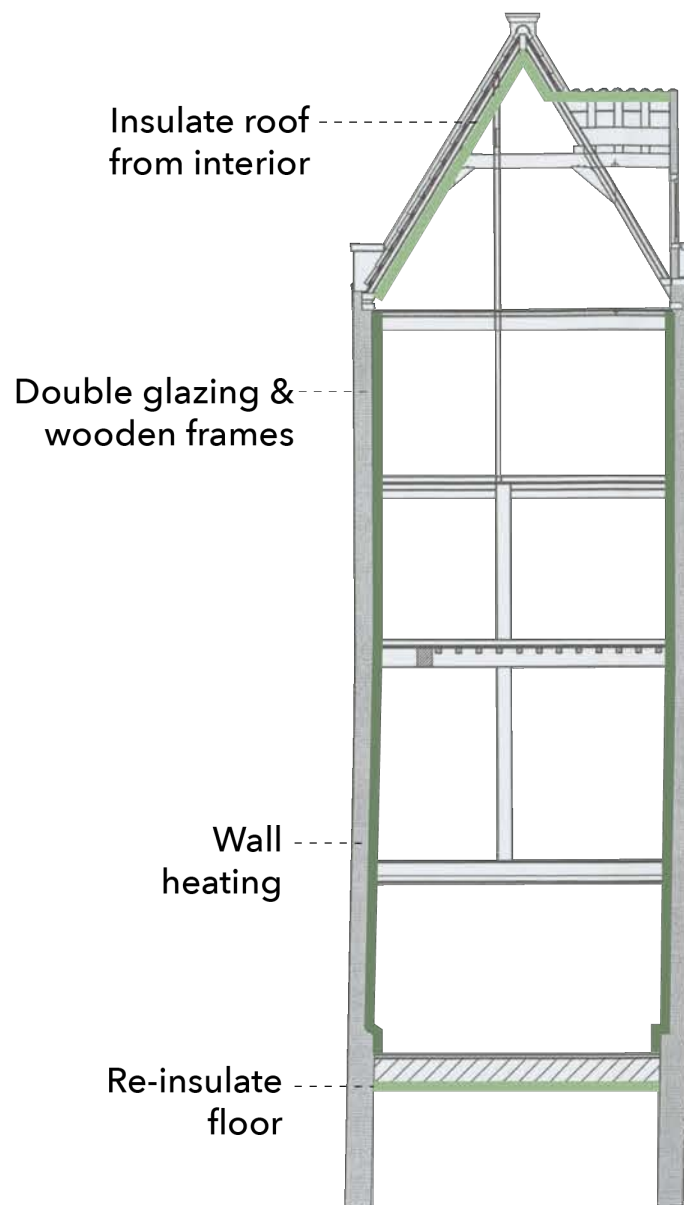


- 1 Plaster finishing (10 mm)
- 2 Plaster & heating pipes in plastic holders (20 mm)
- 3 Existing brick wall

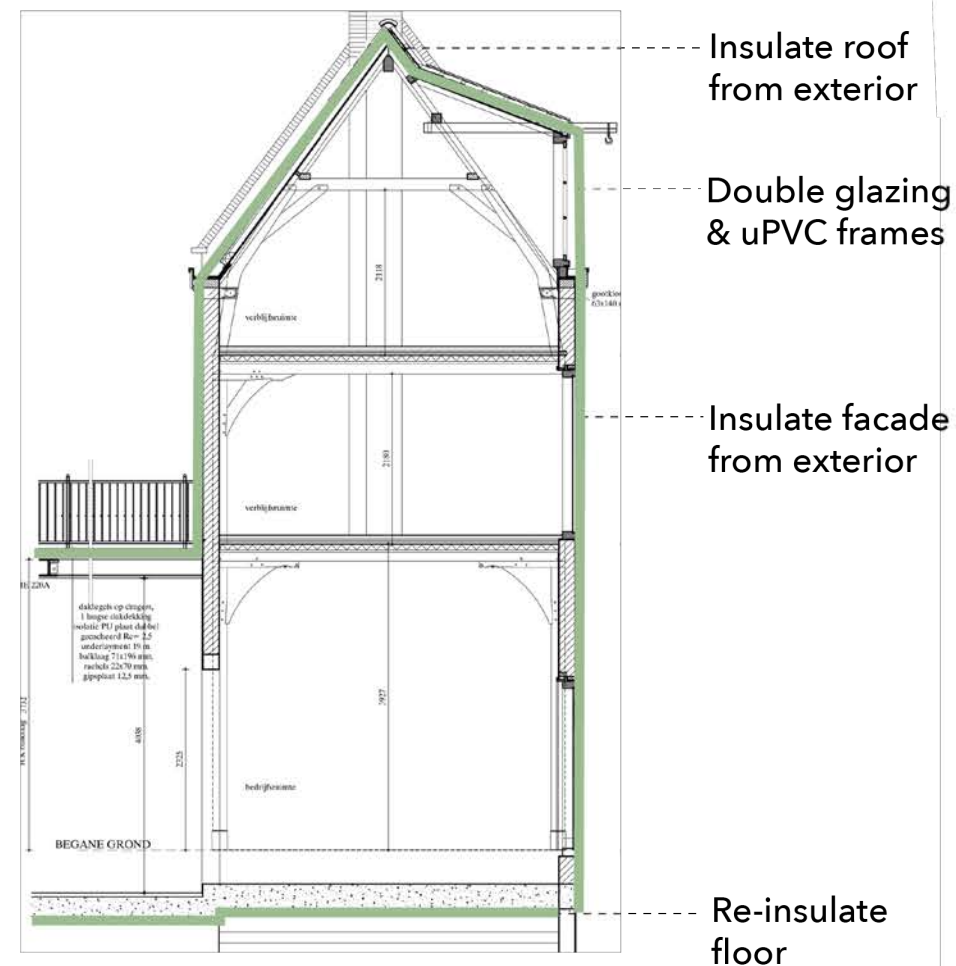
Back house



- 1 Existing wall finishing
- 2 Existing brick wall
- 3 EPS insulation (140 mm)
- 4 Plaster (20 mm)



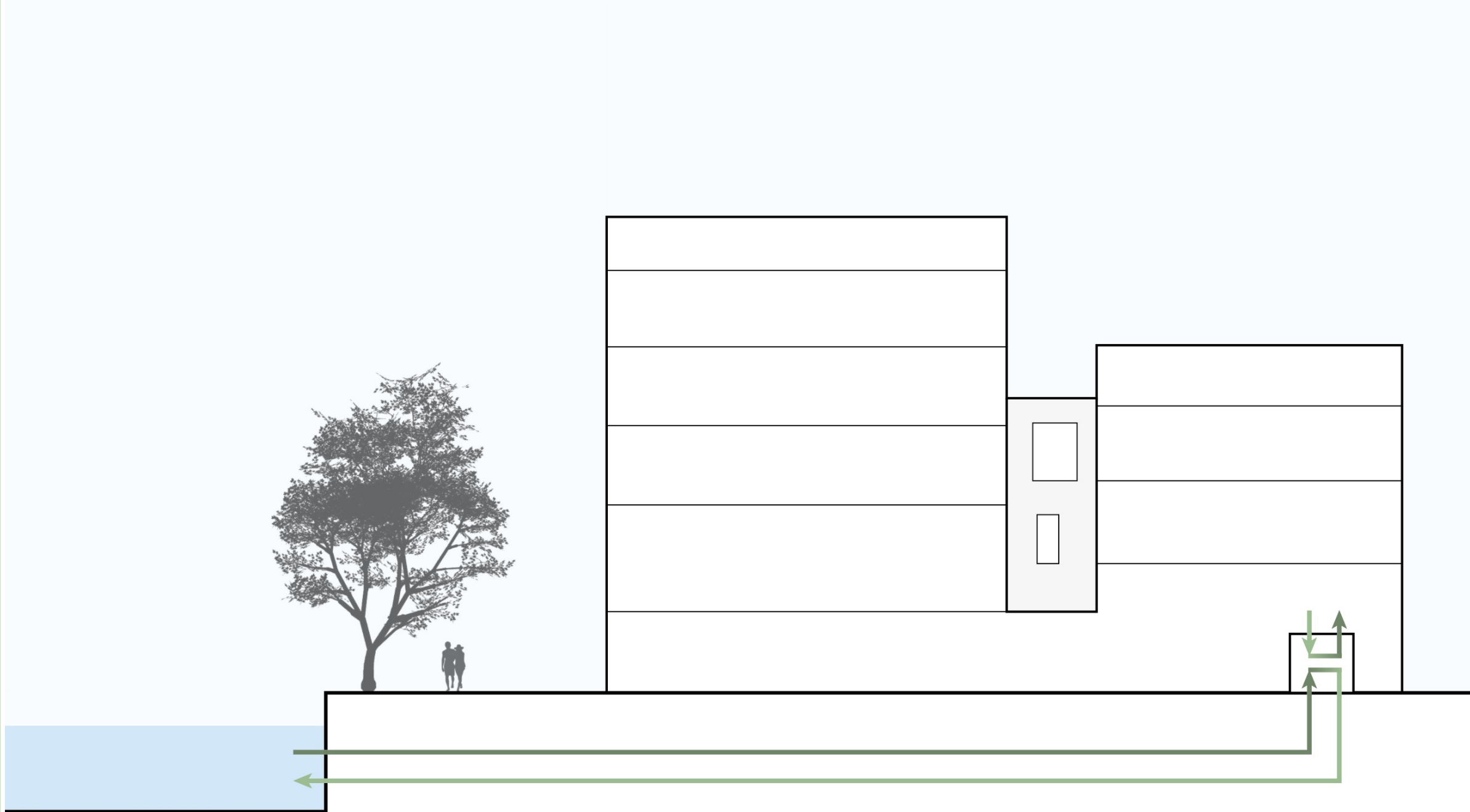
Front house

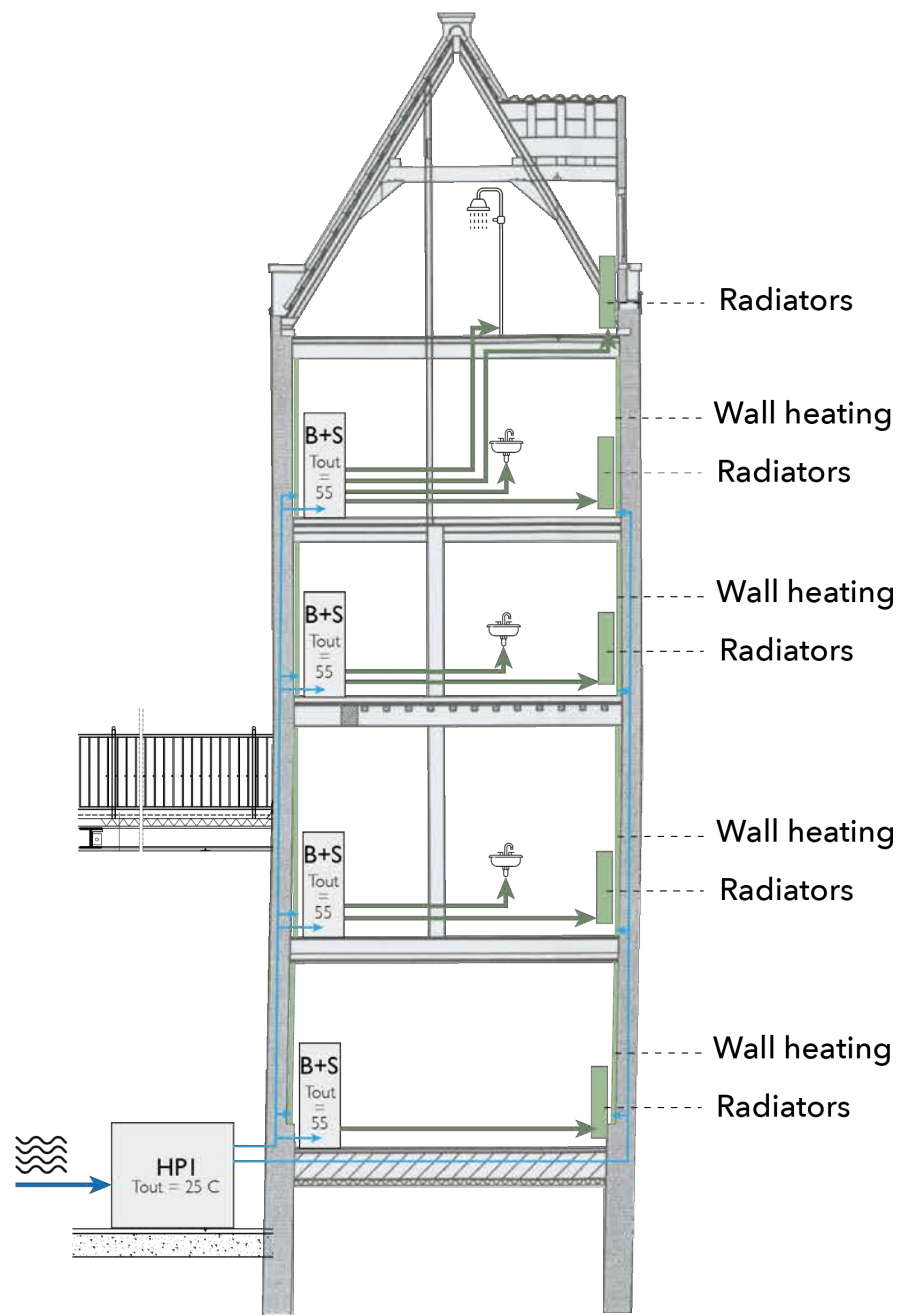


Back house

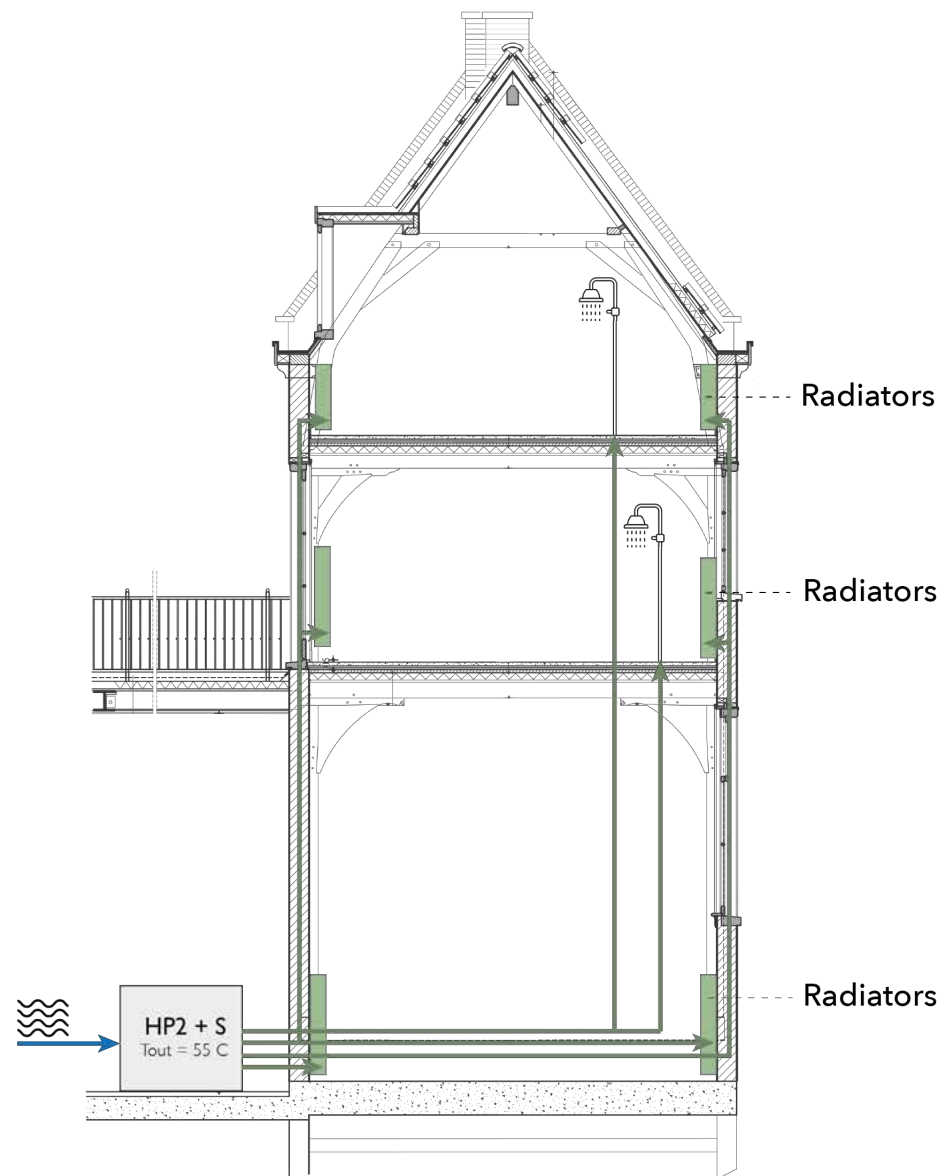


DESIGN PROPOSAL





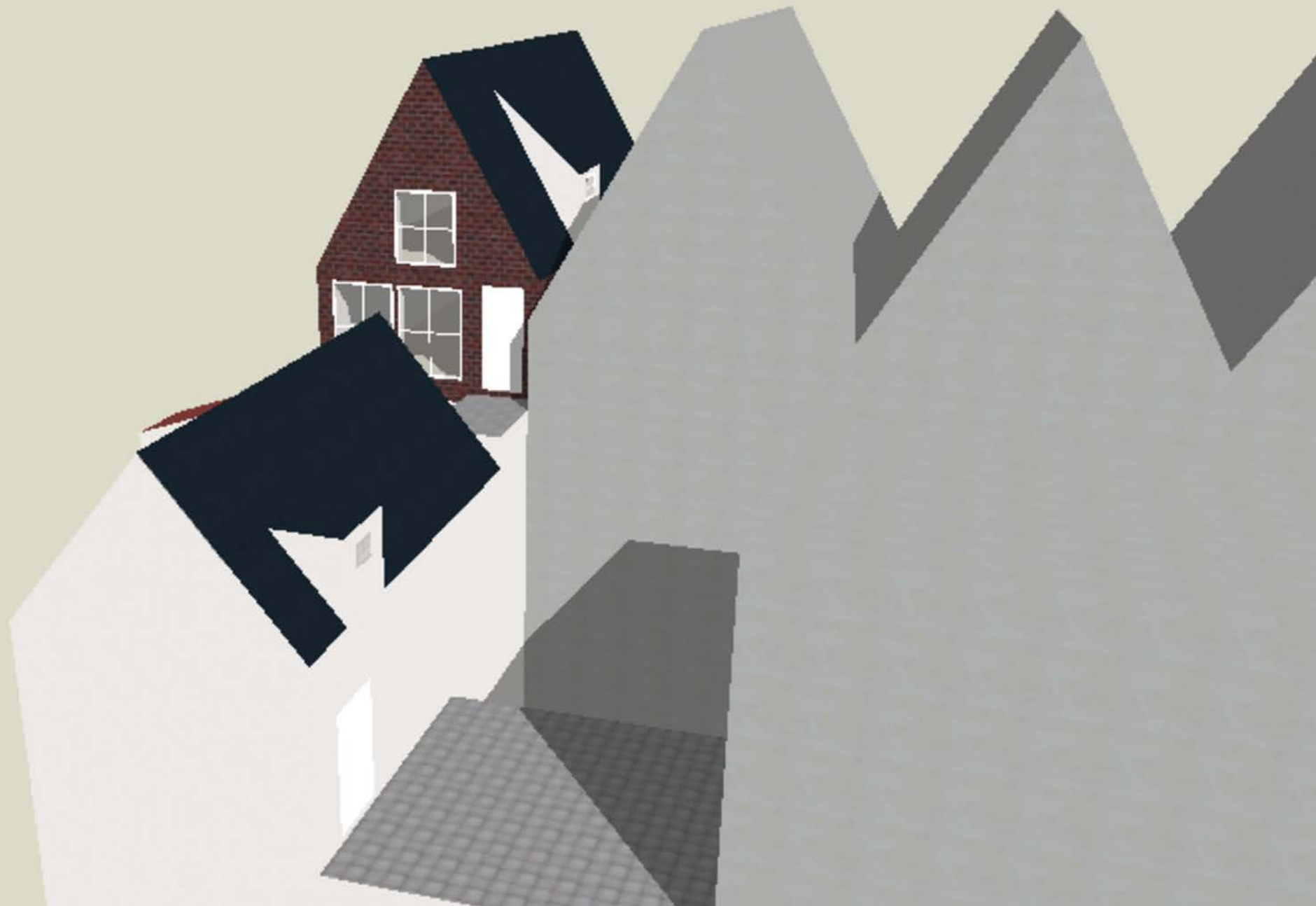
Front house

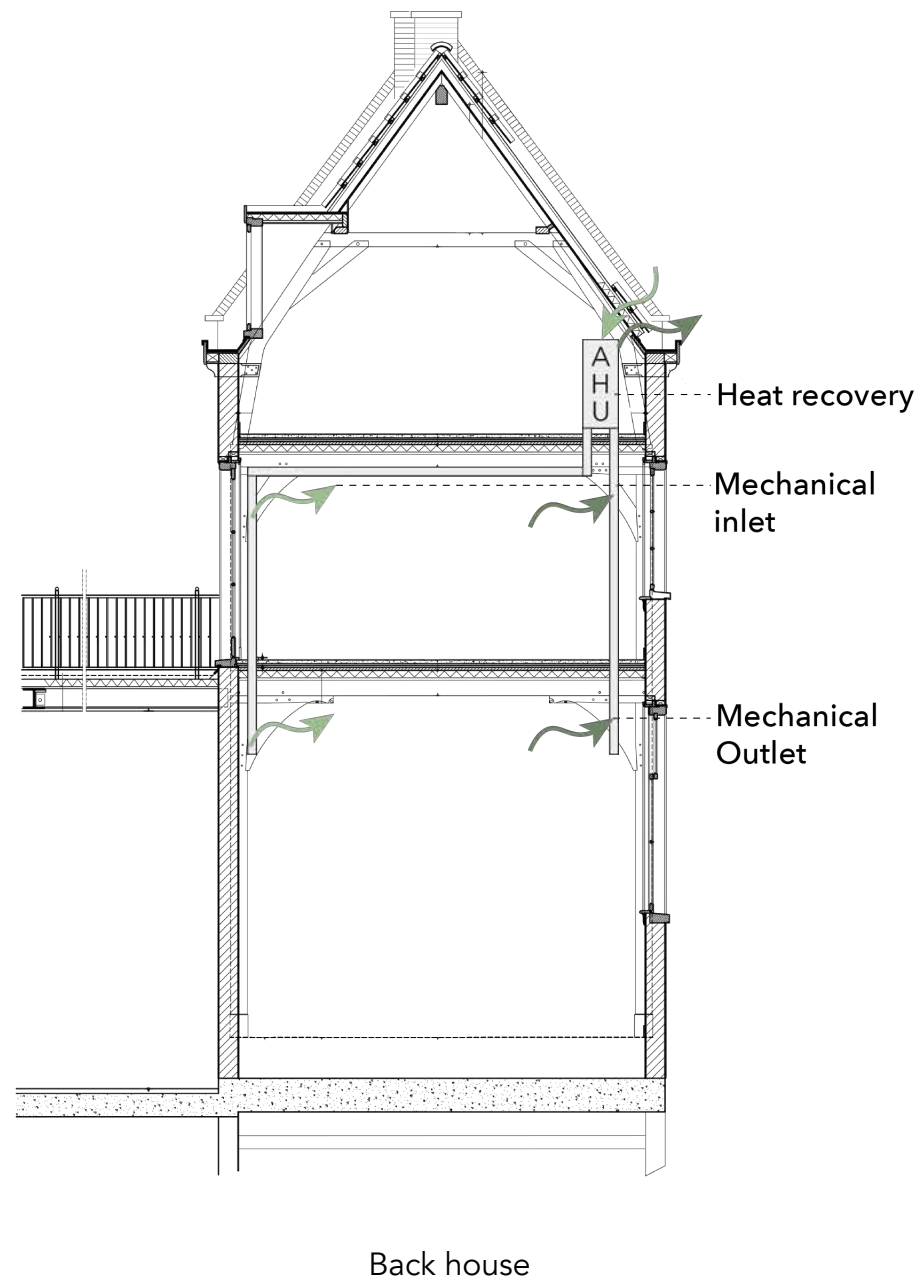
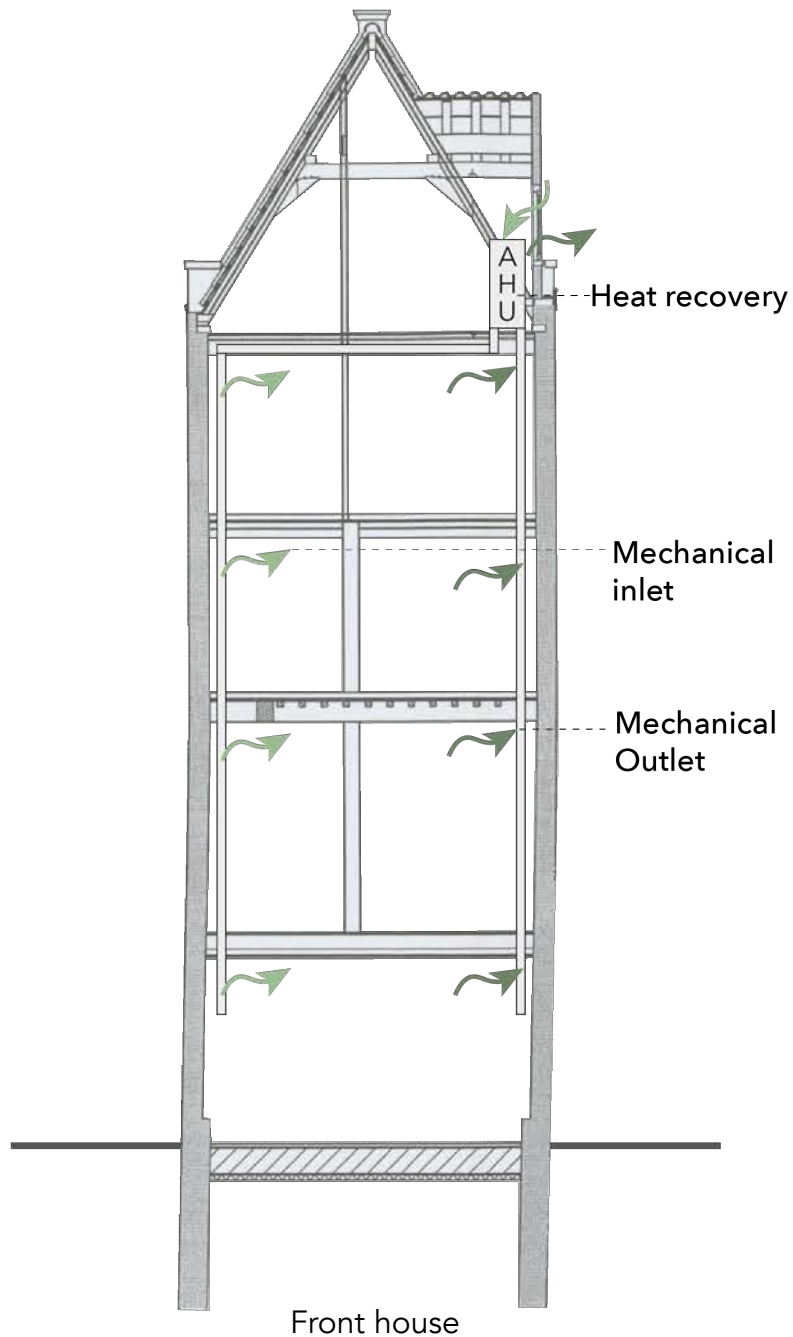


Back house



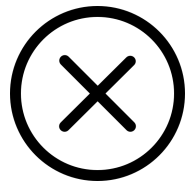
DESIGN PROPOSAL







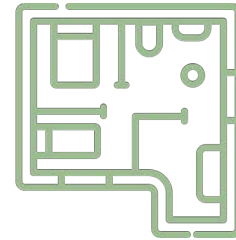
Urban



PV tiles visible
from street



Exterior



Interior



Structure



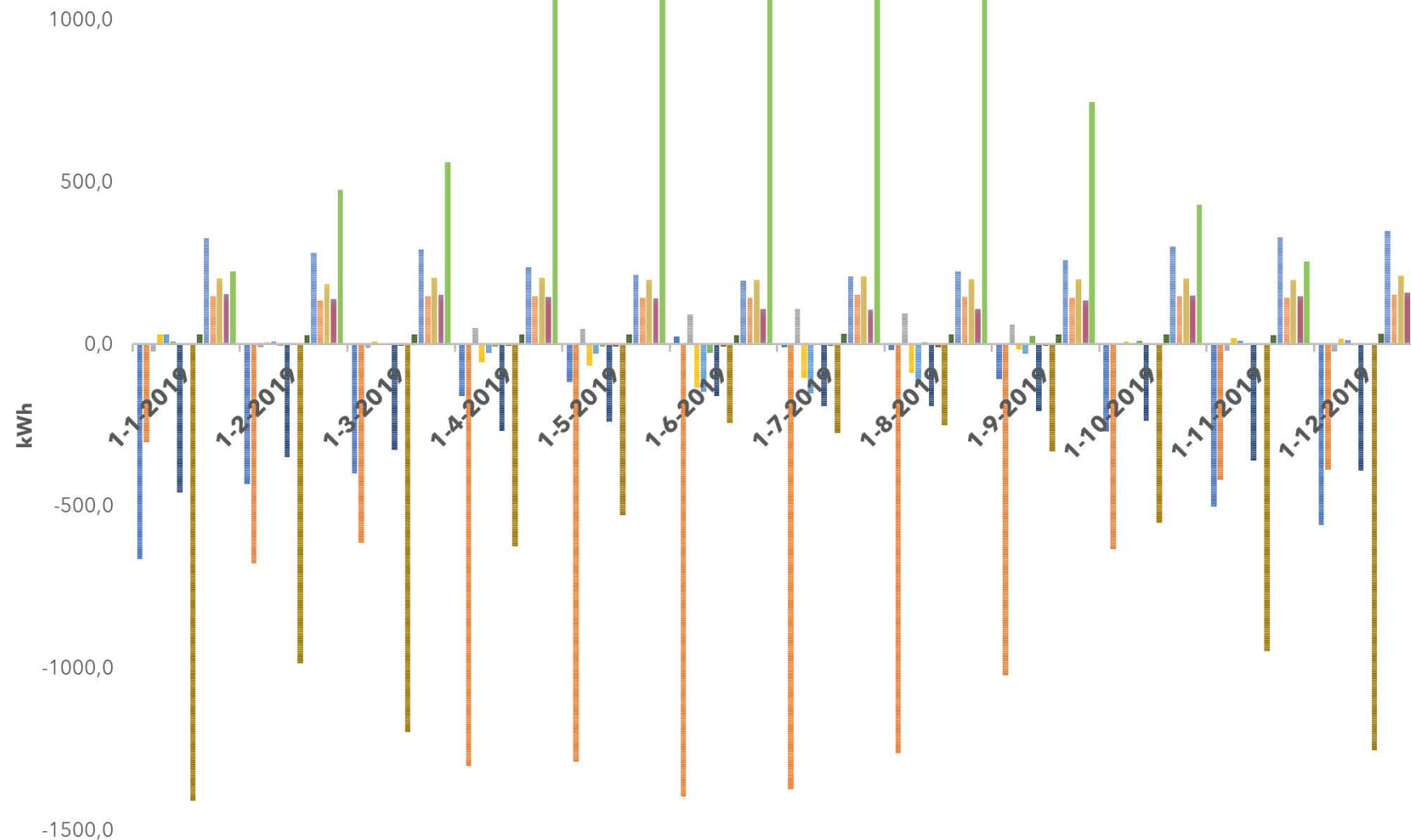


Monthly energy usage						
	Room Electricity	Lighting	System Fans	System Pumps	Heating	Production
	kWh	kWh	kWh	kWh	kWh	kWh
01-01-2019	352,4	359,1	67,7	4,0	4237,9	
01-02-2019	320,0	310,3	61,1	2,9	2947,9	
01-03-2019	352,8	322,6	67,7	2,9	2844,2	
01-04-2019	355,0	268,6	65,5	1,7	1343,9	
01-05-2019	343,2	244,1	67,7	1,5	1023,4	
01-06-2019	341,8	226,2	65,5	0,9	218,4	
01-07-2019	361,1	240,9	67,7	0,9	175,5	
01-08-2019	348,0	254,2	67,7	0,9	161,0	
01-09-2019	345,8	290,6	65,5	1,0	383,7	
01-10-2019	352,4	333,3	67,7	1,8	1537,2	
01-11-2019	341,8	358,9	65,5	3,0	3154,0	
01-12-2019	365,9	381,1	67,7	3,5	3645,2	
Total energy usage (kWh)						
2019 (COP = 3,5)	4180,3	3589,9	797,0	24,9	21672,1	-16112,2
Total energy usage yearly (kWh)						
Total usage	30264,1					
Total production	-16112,2					
Total demand	14151,9					



ENERGY PERFORMANCE

- Glazing kWh
- Floors (int) kWh
- Roofs kWh
- Task Lighting kWh
- Computer + Equip kWh
- Walls kWh
- Ground Floors kWh
- Internal Natural vent. kWh
- General Lighting kWh
- Occupancy kWh
- Ceilings (int) kWh
- Partitions (int) kWh
- External Infiltration kWh
- Miscellaneous kWh
- Solar Gains Exterior Windows kWh



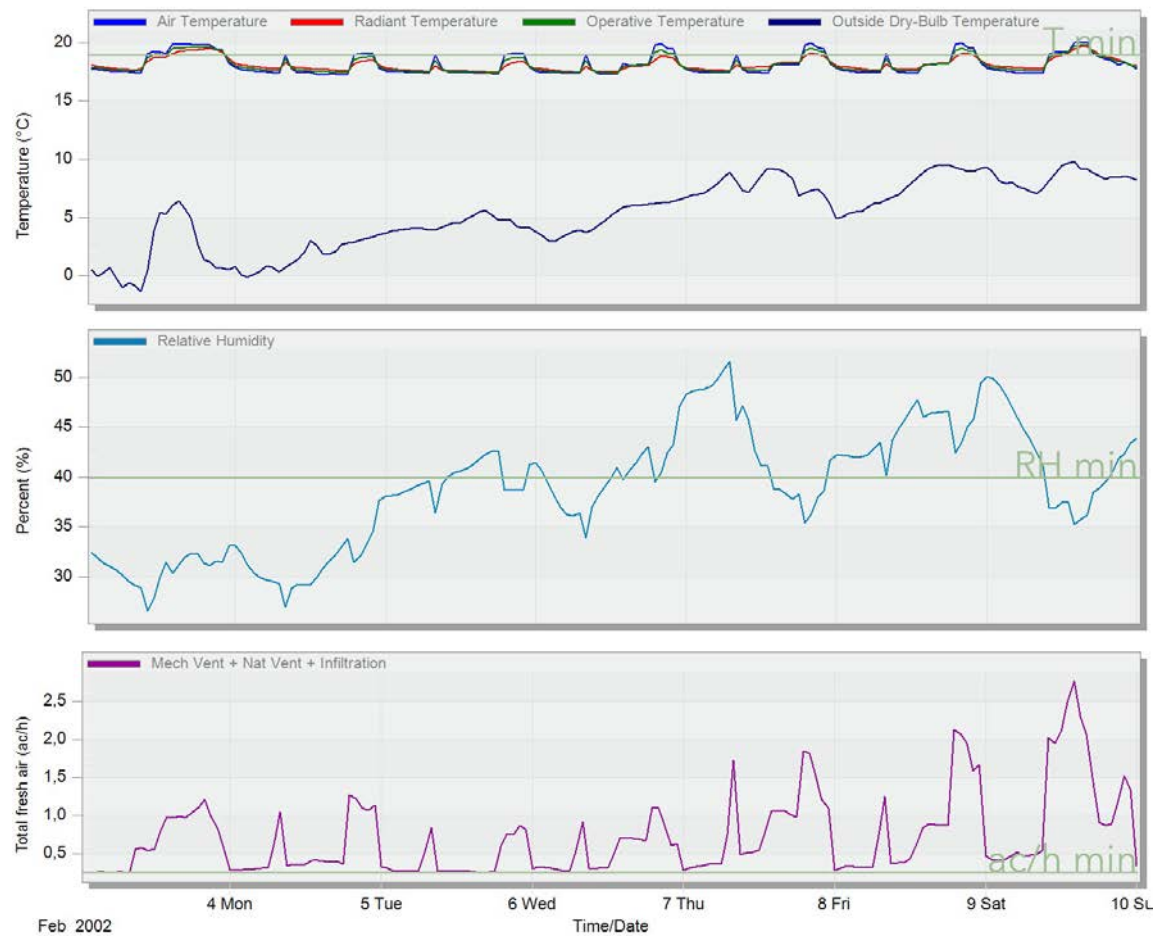


Yearly energy usage				
	Energy usage current	Energy usage renovation	Difference	Decrease/increase
	kWh	kWh	kWh	%
User related energy	13896,2	7770,2	-6126	-44,1%
Systems	22,1	821,9	799,8	3792,8%
Heating	58373,2	21672,1	-36701,1	-62,9%
Production visible	0	-2257,2	-2257,2	N.A.
Production non visible	0	-13855	-13855	N.A.
Material related energy	0	5318,4	5318,4	N.A.
Building related energy	72291,6	30264,2	-42027,4	-58,1%
Energy demand	72291,6	14152	-58139,6	-80,4%
Total (incl. PV & MRE)	72291,6	19470,4	-52821,2	-73,1%

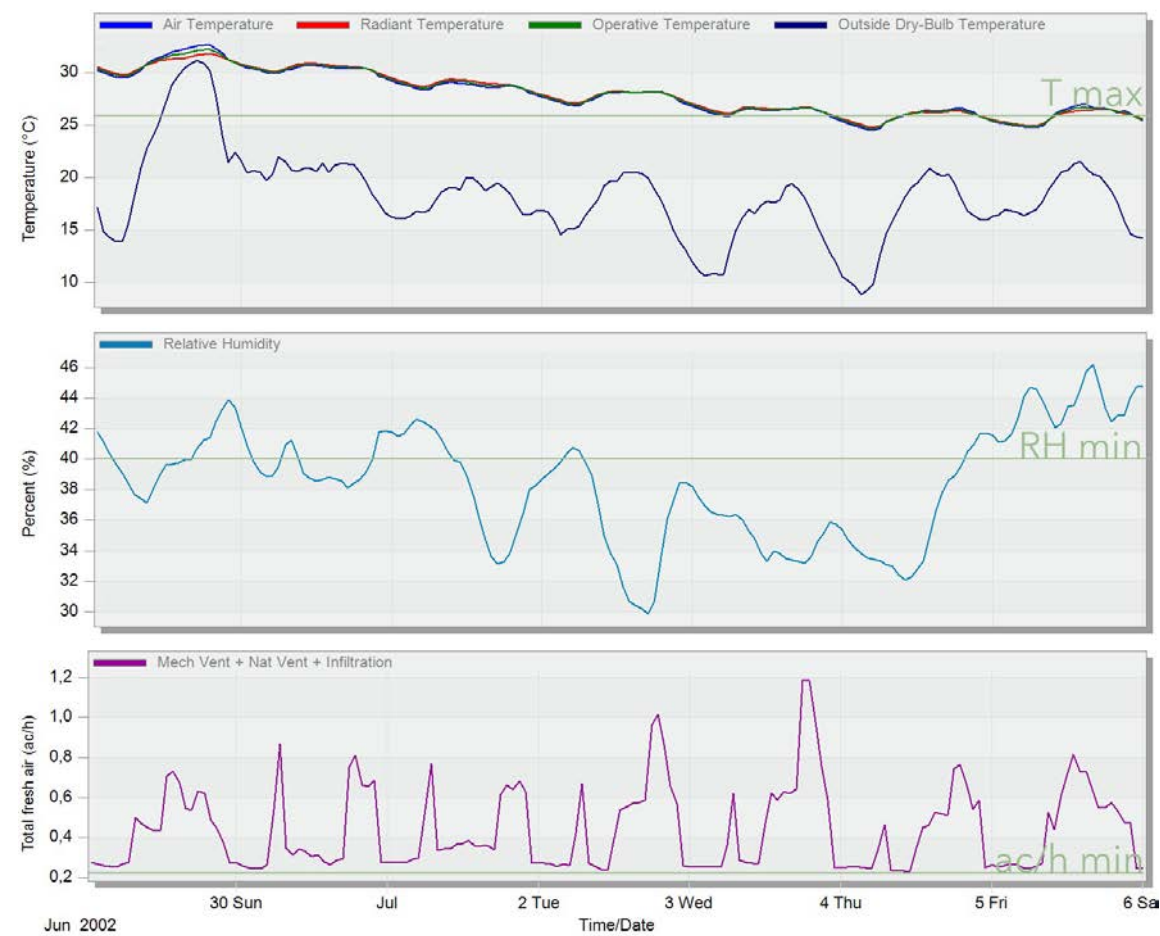
		Criteria	Renovation
BENG 1	Energy demand in kWh/m2	Max. 84,8	61,8
BENG 2	Primary energy demand in kWh/m2	Max. 50	38,6
BENG 3	% renewables	Min. 40%	41,7%



INDOOR COMFORT



Winter



Summer





Monumentality

- No monumental elements altered
- Does not adhere to protected city view regulations



Energy performance

- Significant energy reduction (-73%)



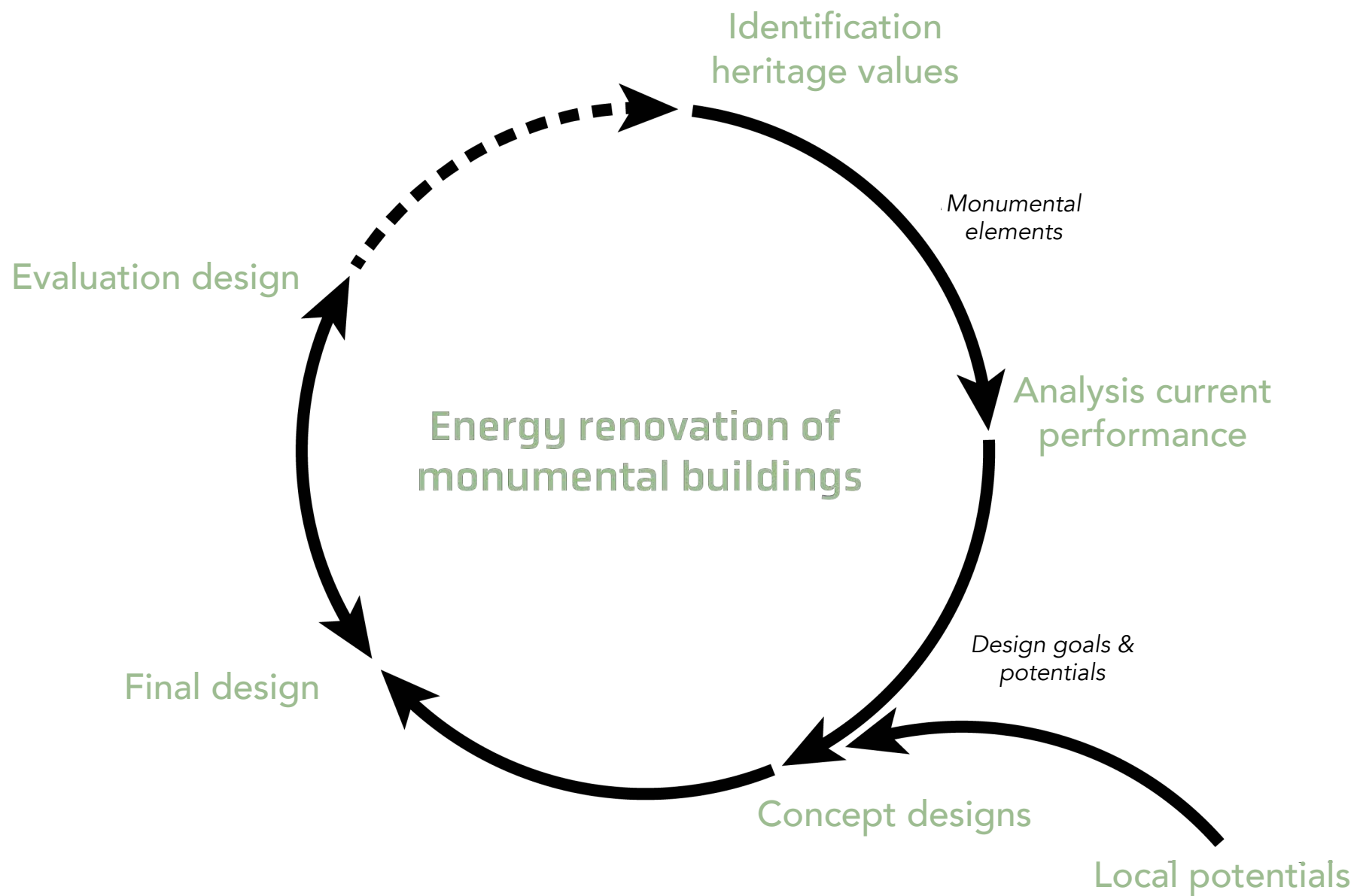
Indoor comfort

- Significant increase in comfort
- Adheres to set criteria

Cost calculation (EUR)

Investment costs	168179
Yearly savings	5486
Payback time	30,7







“How can monumental buildings be renovated to become energy neutral and comfortable for the users, whilst preserving the monumental status?”

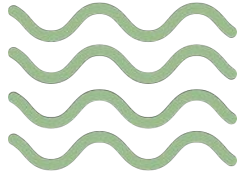




"How far should we go to preserve our past if it limits or even damages our future?"



Limitations



Uncertain
performance



Uncertain
performance



Design not
financially driven

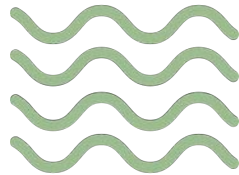


Simplified
simulation

Future research



More thorough analysis
of concepts



Solution for buildings
not near water



ATES & cooling



Application in other
buildings



Thank you for listening

