

## BUILDING INFORMATION

Category:	Residential
Status:	in planning
Building type:	New construction
Year of construction:	0
Units:	1
Number of occupants:	3 (Design)
Occupant density:	51 $m^2$ /Person

## Boundary conditions

Climate:	User defined
Internal heat gains:	2.3 $W/m^2$
Interior temperature:	20 $^{\circ}C$
Overheat temperature:	25 $^{\circ}C$

## Building geometry

Enclosed volume:	590.4 $m^3$
Net-volume:	463.4 $m^3$
Total area envelope:	439.2 $m^2$
Area/Volume Ratio:	0.7 $1/m$
Floor area:	153 $m^2$
Envelope area/ICFA:	2.871

## PASSIVEHOUSE REQUIREMENTS

Certificate criteria: Phius CORE 2021

## Heating demand

<b>Specific:</b>	5.07 kWh/m <sup>2</sup> a
<b>Target:</b>	15 kWh/m <sup>2</sup> a
<b>Total:</b>	776.17 kWh/a

## Cooling demand

<b>Sensible:</b>	11.39 kWh/m <sup>2</sup> a
<b>Latent:</b>	3.29 kWh/m <sup>2</sup> a
<b>Specific:</b>	14.69 kWh/m <sup>2</sup> a
<b>Target:</b>	15 kWh/m <sup>2</sup> a
<b>Total:</b>	2,246.53 kWh/a

## Heating load

<b>W/m<sup>2</sup>:</b>	8.66 W/m <sup>2</sup>
<b>Target:</b>	10 W/m <sup>2</sup>
<b>Total:</b>	1,325.03 W

## Cooling load

<b>Specific:</b>	9.71 W/m <sup>2</sup>
<b>Total:</b>	W/m <sup>2</sup>

## Annual Heat Demand

Item	Value (kWh/a)
Transmission losses	5,455
Ventilation losses	1,216
Total heat losses	6,671
Solar heat gains	5,455
Internal heat gains	1,270
Total heat gains	6,725
Utilization factor	87.7%
Useful heat gains	5,895
Annual heat demand	776
Specific annual heat demand	5.1

## Annual Cooling Demand

Item	Value (kWh/a)
Solar heat gains	2,242
Internal heat gains	2,482
Total heat gains	4,724
Transmission losses	2,928
Ventilation losses	509
Total heat losses	3,437
Utilization factor	86.7%
Useful heat losses	2,981
Cooling demand - sensible	1,743
Cooling demand - latent	503
Annual cooling demand	2,247
Specific annual cooling demand	14.7

## Source Energy

- Total: 11,649.6 kWh/a
- Specific: 3,883 kWh/Person a
- Target: 4,850 kWh/Person a
- Specific: 76.15 kWh/m<sup>2</sup>a

## Site Energy

- Total: 6,472 kWh/a
- Specific: 42.31 kWh/m<sup>2</sup>a

## Air Tightness

- ACH<sub>50</sub>: 0.85 1/h
- CFM<sub>50</sub> per envelope area: 0.9 m<sup>3</sup>/m<sup>2</sup>h
- Target: 1.04 1/h
- Target CFM<sub>50</sub>: 1.1 m<sup>3</sup>/m<sup>2</sup>h

## Passive House Recommendations

- Sensible Recovery Efficiency: 75.7%
- Frequency of Overheating: 33.4%  
*Cooling system is required.*

*Frequency of overheating only applies if there is not a [properly sized] cooling system installed.*

## Building Elements

### Windows

Average SHGC	0.47
Average Solar Reduction Factor (Heating)	0.51
Average Solar Reduction Factor (Cooling)	0.1
Average U-value	0.799 W/m <sup>2</sup> K
Total Glazing Area	53.8 m <sup>2</sup>
Total Window Area	67.9 m <sup>2</sup>

### HVAC

Total Heating Demand	776 kWh/a
Total Cooling Demand	2,247 kWh/a
Total DHW Energy Demand	2,824 kWh/a
Solar DHW Contribution	0 kWh/a
Auxiliary Electricity	231 kWh/a

### Electricity

Direct Heating / DHW	2,288 kWh/a
Cooling	478 kWh/a
HVAC Auxiliary Energy	231 kWh/a
Appliances	3,476 kWh/a
Renewable Generation	0 kWh/a
Total Electricity Demand	6,472 kWh/a

## Heat Flow - Heating Period

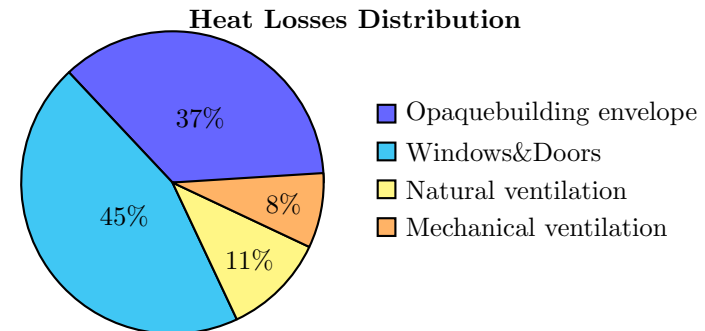
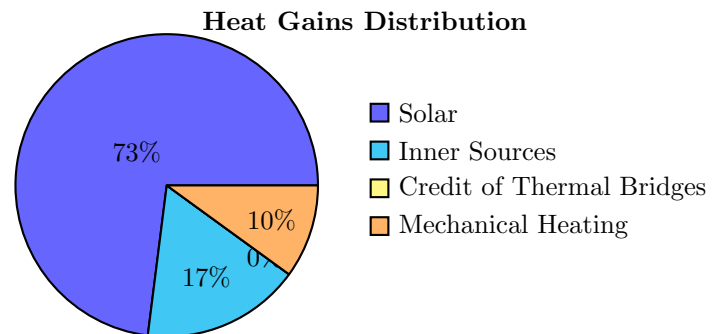
### Heat Gains

Solar	4,781 kWh/a
Inner Sources	1,114 kWh/a
Credit of Thermal Bridges	0 kWh/a
Mechanical Heating	776 kWh/a

### Heat Losses

Opaque Building Envelope	2,443 kWh/a
Windows & Doors	2,957 kWh/a
Natural Ventilation	712 kWh/a
Mechanical Ventilation	504 kWh/a

### Pie Charts



## CLIMATE

- Latitude: 42.6 °
- Longitude: 27.5 °

- Elevation of weather station: 41.1 m
- Elevation of building site: 41.1 m
- Heat capacity air: 0.33 Wh/m<sup>2</sup>K
- Daily temperature swing summer: 8 K
- Average wind speed: 4.1 m/s

## Ground

- Average ground surface temperature: 14.1 °C
- Amplitude ground surface temperature: 10.8 °C
- Ground thermal conductivity: 2 W/mK
- Ground heat capacity: 2 MJ/m<sup>2</sup>K
- Depth below grade of groundwater: 3 m
- Flow rate groundwater: 0.1 m/d

## Calculation parameters

- Length of heating period: 151 days/a
- Heating degree hours: 59.2 kWh/a
- Phase shift months: 1.3 months
- Time constant heating demand: 223.3 h
- Time constant cooling demand: 0 h
- Time constant cooling demand with night ventilation: 0 h

## SPECIFIC HEAT/COOLING DEMAND MONTHLY

Climate for	Heating load 1	Heating load 2	Cooling
Temperature [°C]	-11.1	-11.1	31
Solar radiation North [W/m <sup>2</sup> ]	49	49	78
Solar radiation East [W/m <sup>2</sup> ]	93	93	108
Solar radiation South [W/m <sup>2</sup> ]	206	206	100
Solar radiation West [W/m <sup>2</sup> ]	109	109	112
Solar radiation Global [W/m <sup>2</sup> ]	124	124	209

Table 8: Relevant boundary conditions for heating load calculation: Heating load 1

Table 9: Annual Heat Demand	
Description	kWh/a
Transmission losses	5,455
Ventilation losses	1,216
Total heat losses	6,671
Solar heat gains	5,455
Internal heat gains	1,270
Total heat gains	6,725
Utilization factor	87.7%
Useful heat gains	5,895
Annual heat demand	776
Specific annual heat demand	5.1 kWh/m <sup>2</sup>

Heating Load

Cooling Load

Energy Balance

AREAS

Degree hours

THERMAL BRIDGES

WINDOWS

Transmission heat losses - windows

Specific Building Envelope



Table 10: Annual Cooling Demand

Description	kWh/a
Solar heat gains	2,242
Internal heat gains	2,482
Total heat gains	4,724
Transmission losses	2,928
Ventilation losses	509
Total heat losses	3,437
Utilization factor	86.7%
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Annual cooling demand	2,247
Specific annual cooling demand	14.7 kWh/m <sup>2</sup>

## Final Energy Analysis

### Cooling Units

Cooling Type	sensible	latent
Air cooling	0 kWh/m <sup>2</sup> a	0 kWh/m <sup>2</sup> a
Recirculation cooling	0 kWh/m <sup>2</sup> a	0 kWh/m <sup>2</sup> a
Additional dehumidification	0 kWh/m <sup>2</sup> a	0 kWh/m <sup>2</sup> a
Panel cooling	11.4 kWh/m <sup>2</sup> a	0 kWh/m <sup>2</sup> a
<b>Sum</b>	11.4 kWh/m <sup>2</sup> a	0 kWh/m <sup>2</sup> a

## VENTILATION

### Energy transportable by supply air

Heating energy	Cooling energy		
Transportable:	9.83 W/m <sup>2</sup>	Transportable:	5.83 W/m <sup>2</sup>
Load:	8.66 W/m <sup>2</sup>	Load:	9.71 W/m <sup>2</sup>

Infiltration pressure test **ACH50:** 0.85 1/h

Table 11: Monthly Heating and Cooling Demand

Month	Heating [kWh/m <sup>2</sup> ]	Cooling [kWh/m <sup>2</sup> ]
January	1.9	0
February	0.9	0
March	0	0
April	0	0
May	0	0.1
June	0	2.8
July	4.8	0
August	5.1	0
September	1.8	0
October	0	0
November	0	0
December	2.2	0

Table 12: Heating Load Data

Parameter	First Climate	Second Climate
Transmission heat losses:	3,004.8 W	3,004.8 W
Ventilation heat losses:	1,301.5 W	1,301.5 W
Total heat loss:	4,306.3 W	4,306.3 W
Solar heat gain:	2,736.5 W	2,736.5 W
Internal heat gain:	244.8 W	244.8 W
Total heat gains heating:	2,981.3 W	2,981.3 W
Heating load:	1,325 W	1,325 W
Relevant heating load:	1,325 W	
Specific heating load:	8.7 W/m <sup>2</sup>	

**Total extract air demand:** 149.4 m<sup>3</sup>/h

**Supply air per person:** 30.58 m<sup>3</sup>/h

**Occupancy:** 3

**Average air flow rate:** 115.16 m<sup>3</sup>/h

Table 13: Cooling Load Data

Parameter	Value
Solar heat gain:	403.1 W
Internal heat gain:	562.1 W
Total heat gains cooling:	965.2 W
Transmission heat losses:	-386.7 W
Ventilation heat losses:	-133.7 W
Total heat loss:	-520.4 W
Cooling load - sensible:	1,485.6 W
Cooling load - latent:	0 W
Relevant cooling load:	1,485.6 W
Specific maximum cooling load:	9.7 W/m <sup>2</sup>

Table 14: Transmission heat losses - areas

Name	Area [m <sup>2</sup> ]	Average U-value [W/m <sup>2</sup> K]	Absorption coefficient	Emission coefficient	Reduction factor sh
VC.1: FLOOR [ground floor]: Horizontal (98.4 m <sup>2</sup> , width 12 m)	98.4	0.271	0.4	0	0
VC.2: ROOF.CEILING [roof]: Horizontal (98.4 m <sup>2</sup> , width 12 m)	96.4	0.115	0.4	0	0
VC.3: WALL [ext wall]: SW (A225°, 17.96 m <sup>2</sup> , width 12 m)	17.96	0.139	0.4	0	0
VC.3: WALL [ext wall]: SE (A135°, 16.48 m <sup>2</sup> , width 8.2 m)	16.48	0.139	0.4	0	0
VC.3: WALL [ext wall]: NE (A45°, 33.48 m <sup>2</sup> , width 12 m)	33.48	0.139	0.4	0	0
VC.3: WALL [ext wall]: NW (A315°, 19.76 m <sup>2</sup> , width 8.2 m)	19.76	0.139	0.4	0	0
VC.3: WALL [ext wall]: SW (A225°, 17.96 m <sup>2</sup> , width 12 m)	17.96	0.139	0.4	0	0
VC.3: WALL [ext wall]: SE (A135°, 16.48 m <sup>2</sup> , width 8.2 m)	16.48	0.139	0.4	0	0
VC.3: WALL [ext wall]: NE (A45°, 33.48 m <sup>2</sup> , width 12 m)	33.48	0.139	0.4	0	0
VC.3: WALL [ext wall]: NW (A315°, 18.95 m <sup>2</sup> , width 8.2 m)	18.95	0.139	0.4	0	0

Category	Value
Ambient heating	54.6
Ground heating	21.2

Average air change rate: 0.25 1/h

Effective ACH ambient: 0.15 1/h

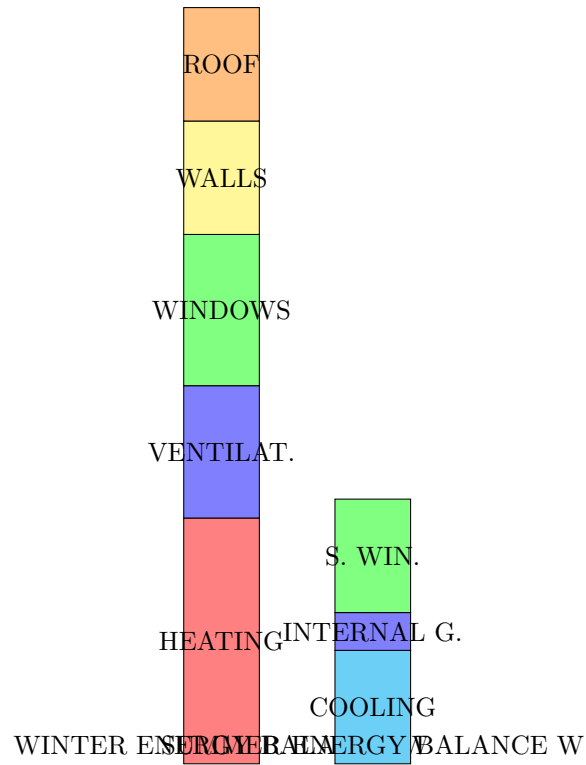


Table 15: Transmission heat losses - thermal bridges

Name	Length [m]	Psi-value [W/mK]	Transmission losses [kWh]	Transmission losses cooling [kWh]
Thermal_Bridges	10	0.1	54.6	26

**Effective ACH ground:** 0 1/h

**Energetically effective air exchange:** 0.09 1/h

**Infiltration air change rate (heating load):** 0.21 1/h

**Type of ventilation system:** Balanced PH ventilation

**Wind screening coefficient (e):** 0.1

Name	Quantity	Inclination [°]	U-value total [W/m²K]	SHGC (perpendicular)	Reduction factor shading [%]	Solar gain h
VC.4 Window: SW (A225°, 6.6 m², width 3 m)	1	90	0.773	0.5	17.9	
VC.4 Window: SW (A225°, 4.84 m², width 2.2 m)	1	90	0.771	0.5	16.9	
VC.4 Window: SW (A225°, 6.6 m², width 2.2 m)	1	90	0.771	0.5	16.9	
VC.4 Window: SE (A135°, 4.4 m², width 2.2 m)	1	90	0.833	0.5	16.9	
VC.4 Window: NE (A135°, 3.72 m², width 1.5 m)	1	90	0.778	0.5	14.7	
VC.4 Window: NE (A15°, 4.5 m², width 2.1 m)	1	90	0.833	0.5	14.0	
VC.4 Window: NE (A15°, 4.5 m², width 1.5 m)	1	90	0.795	0.5	14.7	
VC.4 Window: NW (A15°, 4.84 m², width 2.2 m)	1	90	0.795	0.5	12.7	
VC.4 Window: NW (A135°, 4.4 m², width 2.1 m)	1	90	0.974	0.5	13.1	
VC.4 Window: NW (A135°, 0.81 m², width 0.9 m)	1	90	0.679	0.5	11.4	
VC.4 Window: NW (A15°, 6.6 m², width 3 m)	1	90	0.774	0.5	17.6	
VC.4 Window: NW (A225°, 4.84 m², width 2.2 m)	1	90	0.797	0.5	15.1	
VC.4 Window: SE (A225°, 6.6 m², width 2.2 m)	1	90	0.771	0.5	16.9	
VC.4 Window: SE (A135°, 4.4 m², width 1.5 m)	1	90	0.855	0.5	12.4	
VC.4 Window: NE (A225°, 0.72 m², width 0.9 m)	1	90	0.871	0.5	18.6	
VC.4 Window: NW (A315°, 4.84 m², width 2.2 m)	1	90	0.661	0.5	7.3	
VC.4 Window: NW (A135°, 2.84 m², width 1.5 m)	1	90	0.763	0.5	6.8	

Table 16: Transmission heat losses - windows

**Wind exposure factor:** 15

**Wind shield factor:** 0.1

**Ventilation heat losses:** 1,318.22 KWh/a

## Devices

Name	Sensible recovery efficiency [%]	Electric efficiency [Wh/m²]	Heat recovery efficiency S-H-X [%]	Effective recovery efficien
Zender.ComfAir.G500.ERV	0.8	0.22	0.8	0.8
Altogether	0.8	0.22	0.8	0.8

## Ducts

Length (total) [m]	Clear cross-section [m²]	U-value [W/m²K]	Assigned ventilation units
18	0.0201	0.24	Zender.ComfAir.G500.ERV

Description	Total area / length	Average U-value / Psi value	Transmission losses
Exterior wall ambient:	174.6 m <sup>2</sup>	0.139 W/m <sup>2</sup> K	1,320.5 kWh/a
Exterior wall ground:	0 m <sup>2</sup>	0.0 W/m <sup>2</sup> K	0.0 kWh/a
Basement:	98.4 m <sup>2</sup>	0.271 W/m <sup>2</sup> K	498.3 kWh/a
Roof:	98.4 m <sup>2</sup>	0.116 W/m <sup>2</sup> K	624.6 kWh/a
Windows:	67.9 m <sup>2</sup>	0.759 W/m <sup>2</sup> K	2,957.3 kWh/a
Doors:	0 m <sup>2</sup>	0.0 W/m <sup>2</sup> K	0.0 kWh/a
Thermal bridge ambient:	10 m	0.1 W/mK	0.0 kWh/a
Thermal bridge perimeter:	0 m	0.1 W/mK	0.0 kWh/a
Thermal bridge floor slab:	0 m	0.0 W/mK	0.0 kWh/a

System	DHW	Final energy demand	Heating	Final energy demand	Performance ratio
	Covered DHW demand [%]	Estimated solar fraction [%]	Covered heating demand [%]	Final energy demand [kWh]	
Heat pump, Main Heat Pump	0	0	100	1,977.1	0.7
Heat pump, Main Heat Pump	100	0	0	310.5	0
sum	100	0	0	2,287.6	

Table 17: Energy Demand Summary

## SUMMER VENTILATION

**ACH night ventilation:** 0 1/h

**ACH natural summer:** 0 1/h

**Mechanical ventilation summer:** 0.2 1/h

**Mechanical ventilation summer with HR:** yes

**Preferred minimum indoor temperature for night ventilation:** 20 °C

**Overheating temperature:** 25 °C

## ELECTRICITY DEMAND - AUXILIARY ELECTRICITY

Type	Quantity	Indoor	Norm demand	Electric demand [kW]	Source energy [kWh]
Ventilation winter	1	yes	0.2	107	192.6
Ventilation Defrost	1	yes	148.1	9.2	16.5
Ventilation summer	1	yes	0.2	114.9	206.8
<b>Total</b>				231.1	416

## ELECTRICITY DEMAND RESIDENTIAL BUILDING

Type	Quantity	Indoor	Norm demand	Electric demand [kW]	Non-electric demand [kW]	Source energy [kWh]
Kitchen cooking	2	yes	0.2	300	0	540
Kitchen dishwasher	2	yes	1.3	107.4	0	193.4
Kitchen fridge/freezer combo	2	yes	1.2	445.3	0	801.5
Laundry - dryer	2	yes		13.5	24.3	801.5
Energy consumed by evaporation	1	no		0	0	811.5
Laundry - washer	2	yes	0.3	39.9	0	61
PHIUS+ Interior Lighting	2	yes		590.1	590.1	1062.2
PHIUS+ Misc Electric Loads	2	yes		1,639.5	1,639.5	2951.2
<b>Total</b>	17			3475.8	13.5	6280.7

## INTERNAL HEAT GAINS

### Heating Season

Description	Value
Electricity total	299.9 W
Auxiliary electricity	2.2 W
People	132 W
Cold water	-8.5 W
Evaporation	-75 W
<b>Total</b>	350.5 W
Specific internal heat gains	2.3 W/m <sup>2</sup>

### Cooling Season

Description	Value
Electricity total	299.9 W
Auxiliary electricity	25.3 W
People	132 W
Cold and hot water	179.9 W
Evaporation	-75 W
<b>Total</b>	350.5 W
Specific internal heat gains	2.3 W/m <sup>2</sup>



## DHW AND DISTRIBUTION

DHW consumption per person per day:	25 Ltr/Person/day
Average cold water temperature supply:	14.1 °C
Useful heat DHW:	1,453 kWh/a
Specific useful heat:	9.5 kWh/m <sup>2</sup> a
Total heat losses of the DHW system:	1,371.4 kWh/a
Specific losses of the DHW system:	9 kWh/m <sup>2</sup> a
Performance ratio DHW distribution system and storage:	1.9
Utilization ratio DHW distribution system and storage:	0.5
Total heat demand of DHW system:	2,824.4 kWh/a
Total specific heat demand of DHW system:	18.5 kWh/m <sup>2</sup> a
Specific heat losses of the hydronic heating distribution:	0 kWh/m <sup>2</sup> a
Performance ratio of heat distribution:	100%

## Hydronic Heating Distribution Losses

Region	Length in [m]	Annual heat loss [kWh]
Hydronic heating distribution pipes	0	0
DHW circulation pipes	7.4	161.7
in conditioned space	7.4	161.7
Individual pipes	7.4	4.9
in conditioned space	7.4	4.9
Water storage		1164.5
Device 2 (Water storage: DHW): Hot Water		1164.5