Passive House-Verification

10.3 EN

PHPP

Building:	End-of-terrace Passive House		
Street:	Example Street 99		
Postcode/City:	99999	Example City	
Province/Country:	Example Province	DE-Germany	
Building type:	4-Row house		
Climate data set:	DE-9999-PHPP-Standard		
Climate zone:	3: Cool-temperate	Altitude of location:	-
Home owner / Client:	Passivhaus Association of Owners		
Street:	Example Street 99		
Postcode/City:	99999	Example City	
Province/Country:	Example Province	DE-Germany	

Architecture:	Example Architectural Firm		
Street:	Example Street 99		
Postcode/City:	99999	Example City	
Province/Country:	Example Province	DE-Germany	
Energy consultancy:	Example Energy Consultant		
Street:	Example Street 99		
Postcode/City:	99999	Example City	
Province/Country:	Example Province	DE-Germany	

Mechanical engineer:	Example Mechanical Services Firm		
Street:	Example Street 99		
Postcode/City:	99999	Example City	
Province/Country:	Example Province	DE-Germany	
Certification:	Passive House Institute		
Street:	Rheinstr. 44/46		
Postcode/City:	64283	Darmstadt	
Province/Country:		DE-Germany	

Year of construction:	2021	Interior temperature winter [°C]:	20.0	Interior temp. summer [°C]:	25.0
No. of dwelling units:	1	Internal heat gains (IHG) winter [W/m²]:	2.4	IHG summer [W/m²]:	2.4
No. of occupants:	2.9	Specific capacity [Wh/K per m² TFA]:	204	Mechanical cooling:	x

Specific building characteristics with reference to the treated floor area

					Criteria	Alternative criteria	Fullfilled?[2]
	Treated floor area	m²	156.0				
Space heating	Heating demand	kWh/(m²a)	**11**	≤	15	-	**Yes**
	Heating load	W/m²	**9**	≤	-	10	
Space cooling	Cooling & dehum. demand	kWh/(m²a)	**0**	≤	15		**Yes**
	Frequency of overheating (> 25 °C)	%	**-**	≤	-		**-**
	Frequency of excessively high humidity (> 12 g/kg)	%	**0**	≤	10		**Yes**
Airtightness	Pressurisation test result n_{50}	1/h	**0.3**	≤	0.6		**Yes**
Non-renewable Primary Energy (PE)	PE demand	kWh/(m²a)	**48**	≤	-		**-**
Primary Energy Renewable (PER)	PER demand	kWh/(m²a)	**37**	≤	30	37	**Yes**
	Generation of renewable energy (in relation to projected building	kWh/(m²a)	**143**	≥	120	133	

I confirm that the values given here have been determined following the PHPP methodology and based on the characteristic values of the building. The PHPP calculations are attached to this verification.

Passive house Premium? **Yes**

Task:	First name:	Surname:	Signature:
1-Design	Example	Example	
Certificate-ID	**Issued on:**	**City:**	
example-ID	02.05.22	Darmstadt	

Climate data

End-of-terrace Passive House / Climate: PHPP-Standard / TFA: 156 m² / Heating: 10.8 kWh/(m²a) / Cooling: 0.1 kWh/(m²a) / PER: 37.4 kWh/(m²a)

Selection of climate data

Country:	DE-Germany
Region:	All
	1-Sort alphabetically
Climate data set:	DE-9999-PHPP-Standard
Climate zone:	3: Cool-temperate

Altitude

Weather station:		m
Building location:		m

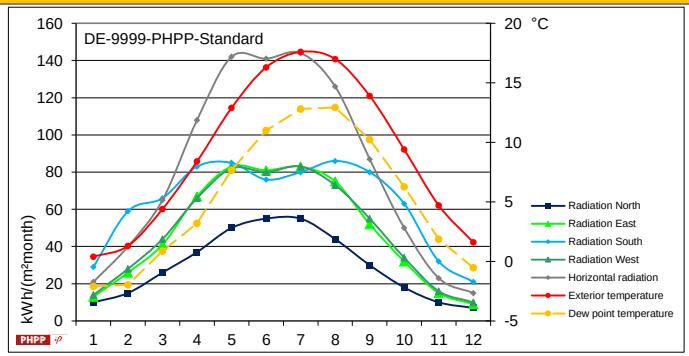
Temperature increase

Summer:		°C

Result overview

Annual heating demand	10.8	kWh/(m²a)
Heating load	8.9	W/m²
Frequency of overheating	-	%
Sensible cooling	0.1	kWh/(m²a)
Latent cooling	0.0	kWh/(m²a)
Cooling load	3.7	W/m²
PER demand	37.4	kWh/(m²a)

	Data for heating Annual method	Data from monthly balance Heating	Cooling	
Heating / cooling period	219	151	48	d/a
Heating / cooling degree hours	82	66	-8	kKh/a
Radiation North	129	68	78	kWh/(m²a)
Radiation East	212	104	130	kWh/(m²a)
Radiation South	359	207	143	kWh/(m²a)
Radiation West	221	112	128	kWh/(m²a)
Horizontal radiation	339	164	225	kWh/(m²a)



Month	1	2	3	4	5	6	7	8	9	10	11	12	Heating load		Cooling load		PER	
Days	31	28	31	30	31	30	31	31	30	31	30	31	Weather 1	Weather 2	Weather 1	Weather 2	factors	
DE-9999-PHPP-Standard	Latitude °	51.30	Longitude °	9.44	Altitude [m]		ΔT Summer [K]			11.7	T Comfort criterion [°C]		Radiation: [W/m²]		Radiation: [W/m²]			
° C Exterior temperature	0.4	1.3	4.4	8.4	12.9	16.3	17.6	17.0	13.9	9.4	4.7	1.6	-10.6	-1.2	24.0	24.0	1.30	Occupant electricity (a
kWh/(m²month) Radiation North	10	15	26	37	50	55	55	44	30	18	10	7	10	5	100	100	1.30	Domestic hot water
kWh/(m²month) Radiation East	13	26	41	67	83	81	83	75	52	32	15	9	30	5	180	180	1.80	Heating
kWh/(m²month) Radiation South	29	59	66	83	85	76	80	86	80	63	32	21	90	10	200	200	1.10	Cooling
kWh/(m²month) Radiation West	14	28	44	66	82	80	83	73	55	34	16	10	35	5	180	180	1.15	Dehumidification
kWh/(m²month) Horizontal radiation	21	40	65	108	142	141	144	126	87	50	23	15	40	10	330	330		
° C Dew point temperature	-2.1	-2.0	0.9	3.2	7.7	11.0	12.8	12.9	10.2	6.3	1.9	-0.5			15.9	15.9		
° C Sky temperature	-9.7	-9.5	-5.4	-2.0	4.3	8.8	11.2	11.4	7.8	2.3	-3.9	-7.4			13.1	13.1		
Comment	Representative of typical climate conditions in Central Europe. This dataset can be used for an assessment independent of the location in Germany.																	
° C Ground temperature (project-specific)	11.6	10.7	9.8	9.2	13.9	14.2	14.9	15.8	16.7	12.4	12.6	12.3	12.3	12.3	14.9	14.9		
Relative humidity	83%	79%	78%	70%	70%	71%	73%	77%	79%	81%	82%	86%						

U-values of building assemblies

End-of-terrace Passive House / Climate: PHPP-Standard / TFA: 156 m² / Heating: 10.8 kWh/(m²a) / Cooling: 0.1 kWh/(m²a) / PER: 37.4 kWh/(m²a)

Show special cases and secondary calculations on the right ->>

Description of building assembly: External wall — Assembly no.: 01ud

Orientation of building assembly (or R_{si})	2-Wall				Interior insulation?	
Adjacent to (or R_{sa})	1-Outdoor air				U-value supplement [W/(m²K)]	
Area section 1	λ [W/(mK)]	Area section 2 (optional)	λ [W/(mK)]	Area section 3 (optional)	λ [W/(mK)]	Thickness [mm]
Interior plaster	0.350					15
Lime sand brick	0.900					360
Polystyrene	0.032					250
Exterior Render	0.800					20
Percentage of sec. 1:	100%	Percentage of sec. 2:		Percentage of sec. 3:		

Heat transmission resistance coefficients

Interior R_{si}: 0.13 m²K/W

Exterior R_{se}: 0.04 m²K/W

Total thickness [cm]: 64.5

U-value [W/(m²K)]: 0.118

Description of building assembly: Roof — Assembly no.: 02ud

Orientation of building assembly (or R_{si})	1-Roof				Interior insulation?	
Adjacent to (or R_{sa})	1-Outdoor air				U-value supplement [W/(m²K)]	
Area section 1	λ [W/(mK)]	Area section 2 (optional)	λ [W/(mK)]	Area section 3 (optional)	λ [W/(mK)]	Thickness [mm]
Chipboard	0.130					50
Blown Mineral Wool	0.040	I-Beam	0.374			400
Gypsum Plasterboard	0.700					13
Percentage of sec. 1:	98%	Percentage of sec. 2:	2.0%	Percentage of sec. 3:		

Heat transmission resistance coefficients

Interior R_{si}: 0.10 m²K/W

Exterior R_{se}: 0.04 m²K/W

Total thickness [cm]: 46.3

U-value [W/(m²K)]: 0.108

Show special cases and secondary calculations on the right ->

Description of building assembly						Assembly no.
Basement ceiling						03ud

Orientation of building assembly (or R_{si})	3-Floor				Interior insulation?	
Adjacent to (or R_{sa})	3-Ventilated				U-value supplement [W/(m²K)]	
Area section 1	λ [W/(mK)]	Area section 2 (optional)	λ [W/(mK)]	Area section 3 (optional)	λ [W/(mK)]	Thickness [mm]
Parquet	0.130					22
Screed	1.050					48
Impact sound insulation	0.040					30
Concrete ceiling	2.100					160
Polystyrene	0.025					100
Plaster Coat	0.800					10
Percentage of sec. 1:	100%	Percentage of sec. 2:		Percentage of sec. 3:		

Heat transmission resistance coefficients

Interior R_{si}:	0.17	m²K/W	**Total thickness [cm]: 37.0**
Exterior R_{se}:	0.17	m²K/W	**U-value [W/(m²K)]: 0.185**

Description of building assembly						Assembly no.
Partition wall						04ud

Orientation of building assembly (or R_{si})	2-Wall				Interior insulation?	
Adjacent to (or R_{sa})	3-Ventilated				U-value supplement [W/(m²K)]	
Area section 1	λ [W/(mK)]	Area section 2 (optional)	λ [W/(mK)]	Area section 3 (optional)	λ [W/(mK)]	Thickness [mm]
Interior plaster	0.350					15
Calcium Silicate Blocks	1.100					175
Insulation	0.040					80
Calcium Silicate Blocks	1.100					175
Interior plaster	0.350					15
Percentage of sec. 1:	100%	Percentage of sec. 2:		Percentage of sec. 3:		

Heat transmission resistance coefficients

Interior R_{si}:	0.13	m²K/W	**Total thickness [cm]: 46.0**
Exterior R_{se}:	0.13	m²K/W	**U-value [W/(m²K)]: 0.375**

U-value supplement for mechanical fasteners

Approximation method acc. to EN ISO 6946

	Fastening element	User-defined (alternative)	
Description	ETICS fasteners		
Material	1-Steel		
Thermal conductivity	50.0		W/(mK)
Diameter	6		mm
Cross-section area	28		mm²
Length inside insulation layer	230		mm
Amount per m²	4.0		1/m²
Insulation layer			
Thickness	275		mm
Thermal conductivity	0.040		W/(mK)
U-value of entire building assembly (uninterrupted)	0.138		W/(m²K)
U-value supplement	**0.010**		W/(m²K)

	Fastening element	User-defined (alternative)	
Description			
Material			
Thermal conductivity			W/(mK)
Diameter			mm
Cross-section area			mm²
Length inside insulation layer			mm
Amount per m²			1/m²
Insulation layer			
Thickness			mm
Thermal conductivity			W/(mK)
U-value of entire building assembly (uninterrupted)			W/(m²K)
U-value supplement			W/(m²K)

	Fastening element	User-defined (alternative)	
Description			
Material			
Thermal conductivity			W/(mK)
Diameter			mm
Cross-section area			mm²
Length inside insulation layer			mm
Amount per m²			1/m²
Insulation layer			
Thickness			mm
Thermal conductivity			W/(mK)
U-value of entire building assembly (uninterrupted)			W/(m²K)
U-value supplement			W/(m²K)

Areas determination

End-of-terrace Passive House / Climate: PHPP-Standard / TFA: 156 m² / Heating: 10.8 kWh/(m²a) / Cooling: 0.1 kWh/(m²a) / PER: 37.4 kWh/(m²a)

Summary

Temp.-zone	Thermal envelope Areas [m²]	Area group	Group no.	Average U-value [W/(m²K)]	Radiation gains Heating period [kWh/a]	Radiation load Cooling period [kWh/a]
	156.00	**Treated floor area**	1		5 months	2 months
A	**11.04**	**North windows**	2	**0.706**	**163**	**210**
A	**0.00**	**East windows**	3			
A	**30.42**	**South windows**	4	**0.712**	**1493**	**595**
A	**2.00**	**West windows**	5	**0.732**	**27**	**25**
A	**0.00**	**Horizontal windows**	6			
A	**0.00**	**Exterior door**	7			
A	**184.28**	**External wall - ambient**	8	**0.118**	**-3**	**68**
B	**0.00**	**External wall ground/basement**	9			
A	**83.41**	**Roof / ceiling - ambient**	10	**0.108**	**-28**	**60**
B	**80.93**	**Floor slab / basement ceiling**	11	**0.185**		
	0.00		12			
	0.00		13			
	0.00		14			
	Thermal bridges, length [m]			Ψ [W/(mK)]		
A	**122.85**	**Thermal bridges ambient**	15	**-0.024**		
P	**0.00**	**Perimeter thermal bridges**	16			
B	**11.35**	**Thermal bridges FS/BC**	17	**0.061**		
Building element towards neighbour, [m²]				[W/(m²K)]		
I	**100.90**	**Building element towards neighbour**	18	**0.375**		
	Total thermal envelope [m2]			[W/(m²K)]		
	392.07	Average U-value of thermal envelope:		**0.190**		

User-defined temperature reduction factors

Zone	Heating-demand	Heating load		Cooling demand		Cooling load	Passive cooling
X							
Y							
Z							

Auxiliary calculation for the determination of temperature reduction factors

Temperature of the adjacent zone [°C]:

Go to building components list

Area input

Area no.	Building assembly description	Assigned to group	Quantity	x (	a [m]	x	b [m]	+	User-determined calculation [m²]	-	User-determined subtraction [m²]	-	Subtraction window areas [m²]	) =	Area [m²]	Building assembly selection: Selection building assembly / Building system	Selection building assembly	U-value [W/(m²K)]	EnerPHit exemption for U-value	Radiation balance input: Deviation from North	Angle of inclination from the horizontal	Orientation	Reduction factor shading	Exterior absorptivity	Exterior emissivity
	Projected building footprint	0-Projected building footprint:	1	x (	7.13	x	11.35	+		-		)		=	80.9	1-Sorting: AS LIST									
	Treated floor area	1-Treated floor area	1	x (		x		+	156.00	-		)		=	156.0										
	Exterior door	7-Exterior door		x (		x		+		-		) -		=		Exterior door				Radiation balance window frames:					
1	External wall south	8-External wall - Ambient	1	x (	7.13	x	10.31	+		-		) -	30.4	=	43.1	01ud-External wall		**0.118**		180	90	South	0.90	0.60	0.90
2	External wall north	8-External wall - Ambient	1	x (	7.13	x	7.48	+		-		) -	11.0	=	42.3	01ud-External wall		**0.118**		0	90	North	0.90	0.60	0.90
3	External wall west	8-External wall - Ambient	1	x (	11.35	x	8.89	+		-		) -	2.0	=	98.9	01ud-External wall		**0.118**		270	90	West	0.90	0.60	0.90
4	Roof	10-Roof/Ceiling - Ambient	1	x (	7.13	x	11.70	+		-		) -	0.0	=	83.4	02ud-Roof		**0.108**		0	14	Hor	1.00	0.70	0.90
5	Basement floor	11-Floor slab / Basement ceiling	1	x (	7.13	x	11.35	+		-		) -	0.0	=	80.9	03ud-Basement ceiling		**0.185**		0	180	Hor			
6				x (		x		+		-		) -	0.0	=											
7	Partition wall	18-Building element towards neighbour	1	x (	11.35	x	8.89	+		-		) -	0.0	=	100.9	04ud-Partition wall		**0.375**		90	90	East			
8				x (		x		+		-		) -	0.0	=											
9				x (		x		+		-		) -	0.0	=											
10				x (		x		+		-		) -	0.0	=											
11				x (		x		+		-		) -	0.0	=											
12				x (		x		+		-		) -	0.0	=											
13				x (		x		+		-		) -	0.0	=											
14				x (		x		+		-		) -	0.0	=											
15				x (		x		+		-		) -	0.0	=											
16				x (		x		+		-		) -	0.0	=											
17				x (		x		+		-		) -	0.0	=											
18				x (		x		+		-		) -	0.0	=											
19				x (		x		+		-		) -	0.0	=											
20				x (		x		+		-		) -	0.0	=											
21				x (		x		+		-		) -	0.0	=											
22				x (		x		+		-		) -	0.0	=											
23				x (		x		+		-		) -	0.0	=											
24				x (		x		+		-		) -	0.0	=											
25				x (		x		+		-		) -	0.0	=											
26				x (		x		+		-		) -	0.0	=											
27				x (		x		+		-		) -	0.0	=											
28				x (		x		+		-		) -	0.0	=											
29				x (		x		+		-		) -	0.0	=											
30				x (		x		+		-		) -	0.0	=											

Aend

Thermal bridge input

Change sorting

No.	Thermal bridge - description	Group No.	Quantity	x (	Length [m]	-	Subtraction length [m]	)=	Length ℓ [m]	User-defined psi value [W/(mK)]	User defined $f_{Rsi=0.25}$ (optional)	or	Selection building system	Detail selection	Ψ-value [W/mK)]	f_{Rsi}-value (R_{si} = 0,25)	f_{Rsi}-value Evaluation
	Interior drain pipes pipes	15-Thermal Bridges Ambient	1	x	6.00			=	6.00	0.098					**0.098**		
1	Ext. wall-basement	15-Thermal Bridges Ambient	1	x (	24.85	-	) =	24.85	-0.039	0.950	or				**-0.039**	**0.950**	
2	Int. wall-basement	17-Thermal Bridges FS/BC	1	x (	11.35	-	) =	11.35	0.061	0.950	or				**0.061**	**0.950**	
3	Partition walls	15-Thermal Bridges Ambient	1	x (	17.36	-	) =	17.36	0.000	0.950	or				**0.000**	**0.950**	
4	Interior ceilings	15-Thermal Bridges Ambient	1	x (	20.25	-	) =	20.25	0.002	0.950	or				**0.002**	**0.950**	
5	Partition wall-roof	15-Thermal Bridges Ambient	1	x (	11.77	-	) =	11.77	0.005	0.950	or				**0.005**	**0.950**	
6	Ext. wall-roof	15-Thermal Bridges Ambient	1	x (	25.27	-	) =	25.27	-0.061	0.950	or				**-0.061**	**0.950**	
7	Ext. wall edge	15-Thermal Bridges Ambient	1	x (	17.36	-	) =	17.36	-0.062	0.950	or				**-0.062**	**0.950**	
8				x (		-	) =				or						
9				x (		-	) =				or						
10				x (		-	) =				or						
11				x (		-	) =				or						
12				x (		-	) =				or						
13				x (		-	) =				or						
14				x (		-	) =				or						
15				x (		-	) =				or						
16				x (		-	) =				or						
17				x (		-	) =				or						
18				x (		-	) =				or						
19				x (		-	) =				or						
20				x (		-	) =				or						

TBend

Tool for conversion of thermal bridges to exterior dimensions

		Example	
	Ψ Interior dimensions	0.027	W/(mK)
	Temperature difference TB	30.000	K
Adjacent area I	Temperature difference ΔϑI	30.000	K
	Exterior - Interior dimensions I	0.400	m
	U-value building assembly I	0.138	W/(m²K)
Adjacent area II	Temperature difference ΔϑII	30.000	K
	Exterior - interior dimensions II	0.300	m
	U-value building assembly II	0.110	W/(m²K)
	Ψ Exterior dimensions	**-0.061**	**W/(mK)**

Auxiliary calculation for interior drain pipes that are ventilated through the roof

Climate		Nominal width: mm	λ W/(mK)	Insulation thickness mm	Reflective coating?	Ψ-value W/(mK)	Length m	Ψ•ℓ W/K
Room temperature °C	20.0	100	0.040	160	x	0.155	6.00	0.930
Ground temperature °C	10.0							
Ambient temperature heating period °C	4.9							
							m	W/K
Limitation of airflow rate in the pipe system:						Total	6.00	0.930
Nominal width mm	100							
Number of parallel pipes	1					Reduction factor sewer temperature		0.663
Capacitance rate W/K	9.3					Reduction factor warming of air		0.952
						Spec. loss with respect to ambient air [W/K]		**0.587**
						This result is automatically transferred to the energy balance		

Heat losses through the ground

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Building section 1

Ground characteristics			
Thermal conductivity	λ	2.0	W/(mK)
Heat capacity	ρc	2.0	MJ/(m³K)
Periodic penetration depth	δ	3.17	m

Climate data			
Avg. indoor temp. winter	θ_i	20.0	°C
Avg. indoor temp. summer	θ_i	25.0	°C
Avg. ground surface temperature	$\theta_{e,m}$	10.0	°C
Amplitude of $\theta_{e,m}$	$\theta_{e,\wedge}$	8.6	°C
Phase shift of θ_e	τ	1.1	Months
Length of the heating period	n	7.2	Months
Heating degree hours - exterior	G_t	81.9	kKh/a

Building data							
Area floor slab / basement ceiling	A	80.9	m²	U-value floor slab / basement ceiling	U_f	0.185	W/(m²K)
Perimeter length	P	25.0	m	TBs floor slab / basement ceiling	$\Psi_B * \ell$	0.70	W/K
Charact. dimension of floor slab	B'	6.47	m				

Floor slab type (select only one)

	Slab on grade							
	Perimeter insulation width/depth	D		m	Orientation of perimeter insulation	horizontal		
	Perimeter insulation thickness	d_n		m	(check only one field)	vertical	x	
	Conductivity perimeter insulation	λ_n		W/(mK)				
	Area of interior wall towards heated	A_{wl}		m²	U-value of interior wall towards heated	U_{wl}		W/(m²K)
	Heated basement or floor slab completely / partially below ground level							
	Area basement wall below ground	A_{wb}		m²	U-value wall below ground	U_{wB}		W/(m²K)
x	**Unheated basement**							
	Area basement wall above ground	AW	0.00	m²	U-value wall above ground	U_W	0.118	W/(m²K)
	Area basement wall below ground	A_{wb}	59.75	m²	U-value wall below ground	U_{WB}	0.600	W/(m²K)
	Area of interior wall towards heated	A_{wl}		m²	U-value of interior wall towards heated	U_{wl}		W/(m²K)
	Air change unheated basement	n	0.20	h^{-1}	U-value basement floor slab	U_{fB}	0.645	W/(m²K)
	Air volume basement	V	120	m³				
	Suspended floor above a ventilated crawl space (at max. 0.5 m below ground)							
	U-value crawl space	U_{Crawl}		W/(m²K)	Area of ventilation openings	εP		m²
	Height of crawl space wall	h		m	Wind velocity at 10 m height	v	4.0	m/s
	U-value crawl space wall	U_W		W/(m²K)	Wind shield factor	f_W	0.05	-
	Area of interior wall towards heated	A_{wl}		m²	U-value of interior wall towards heated	U_{wl}		W/(m²K)

Perimeter thermal bridges							
				Perimeter TBs steady-state fraction	$\Psi_{P,stat} * \ell$	0.000	W/K
Phase shifting (optional)	β		Months	Perimeter TBs harmonic fraction	$\Psi_{P,harm} * \ell$	0.000	W/K

Groundwater correction							
Depth of the groundwater table	z_w	3.0	m	Groundwater correction factor	G_w	1.03386917	-
Groundwater flow rate	q_w	0.05	m/d				

Interim results

Steady-state conductance	H_S	12.19	W/K	Conductance building	H_0	15.70	W/K
Exterior periodic conductance	H_{pe}	3.79	W/K	Internal harmonic conductance	H_{pi}	13.51	W/K
External phase shift	β	1.20	Months	Internal phase shift	α	0.25	Months

Total result (all building elements)

Steady-state conductance	H_S	12.19	W/K	Conductance building	H_0	15.70	W/K
Exterior periodic conductance	H_{pe}	3.79	W/K	Internal harmonic conductance	H_{pi}	13.51	W/K
External phase shift	β	1.20	Months	Internal phase shift	α	0.25	Months
Steady-state heat flow	Φ_{stat}	144.9	W	Heat losses during heating period	Q_{tot}	728	kWh
External periodic heat flow	$\Phi_{harm,e}$	13.3	W	Charact. dimension of floor slab	B'	6.47	m
Internal harmonic conductance	$\Phi_{harm,i}$	19.6	W				

Heat flow into the ground for monthly method (all building parts)

Month	1	2	3	4	5	6	7	8	9	10	11	12	Avg. value
heat flow	**131**	**146**	**160**	**170**	**174**	**169**	**159**	**144**	**130**	**120**	**116**	**120**	**145**

Design ground temperature for 'Heating load' worksheet 12.3 **For 'Cooling load' worksheet** 14.9

Temperature reduction factor for 'Annual Heating' worksheet 0.57

Passive House Components

End-of-terrace Passive House / Climate: PHPP-Standard / TFA: 156 m² / Heating: 10.8 kWh/(m²a) / Cooling: 0.1 kWh/(m²a) / PER: 37.4 kWh/(m²

◄ Contents Link to 'Areas' worksheet

Building assemblies (U-values)

Typical for climate zone 'Cool-temperate': U-value for walls and roofs 0.15 W/(m²K)

		1			
ID	**Building system**	**Building assembly**	**Total thickness**	**U-value**	**Interior insulation**
	Summary of building assemblies calculated in 'U values' worksheet		m	W/(m²K)	-
01ud	External wall	External wall	0.645	0.118	0
02ud	Roof	Roof	0.463	0.108	0
03ud	Basement ceiling	Basement ceiling	0.370	0.185	0
04ud	Partition wall	Partition wall	0.460	0.375	0
05ud					
06ud					
07ud					
08ud					
09ud					
10ud					
11ud					
12ud					
13ud					

Glazing and entrance doors

Typical for 'Cool-temperate' climate zone: Triple low-e glazing			
ID	**Description**	**g-value**	**U_g-value**
			W/(m²K)
01ud	Triple-low-e Kr08	0.50	0.70
02ud	Triple-low-e Kr12	0.50	0.58
03ud			
04ud			
05ud			
06ud			
07ud			
08ud			
09ud			
10ud			
11ud			
12ud			
13ud			

Window and door frames

					Frame: opening casement (see comment)										Frame: fixed glazing								Mullion frame profile								Transom frame profile						Installation thermal bridges								
		Glazing edge			Left si		Right si		Top to		Bottom bo		Threshold th		Left fixed sif		Right fixed sif		Top fixed tof		Bottom fixed bof		Floating mullion fm		Mullions with 2 openings m2		Mullions with 1 opening m1		Mullions m		Transom with 2 openings t2		Transom with 1 opening t1		Transom t		Opening casement				Fixed glazing				Curtain-wall façades
ID	Description	Spacer Description	Ψ_g (average)	min. f_{Rsi}	Width	U_f	Width	U_f	Width	U_f	Width	U_f	Width	U_f	Width	U_f	Width	U_f	Width	U_f	Width	U_f	Width	U_f	Width	U_f	Width	U_f	Width	U_f	Width	U_f	Width	U_f	Width	U_f	Width	U_f	$\Psi_{installed}$ sides	$\Psi_{installation}$ top	$\Psi_{installation}$ bottom	$\Psi_{installed}$ threshold	$\Psi_{installed}$ sides	$\Psi_{installation}$ top	$\Psi_{installation}$ bottom	χ_{GC} -value Glass carrier
			W/(mK)	-	mm	W/(m²K)	mm	W/(m²K)	mm	W/(m²K)	mm	W/(m²K)	mm	W/(m²K)	mm	W/(m²K)	mm	W/(m²K)	mm	W/(m²K)	mm	W/(m²K)	mm	W/(m²K)	mm	W/(m²K)	mm	W/(m²K)	mm	W/(m²K)	mm	W/(m²K)	mm	W/(m²K)	mm	W/(m²K)	mm	W/(m²K)	W/(mK)				W/(mK)			W/K
01ud	Wooden frame + PU casing	Spacer X	0.049		145	0.59	145	0.59	145	0.59	175	0.61	175	0.64	125	0.59	125	0.59	125	0.59	175	0.61							180	0.61									0.005	0.005	0.020	0.020	0.005	0.005	0.020	
02ud	Wider wooden frame + PU casing	Spacer X	0.049		160	0.59	160	0.59	160	0.59	160	0.61	160	0.64	140	0.59	140	0.59	140	0.59	175	0.61			200	0.61											0.005	0.005	0.020	0.020	0.005	0.005	0.020	
03ud																																														
04ud																																														
05ud																																														
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13ud																																														

Ventilation units

Ventilation units

Typical for climate zone 'Cool-temperate': Frost protection: Yes, Energy recovery: No		75 %				0.45	Additional device data								
		Heating period		Cooling period											
ID	Description	Heat recovery efficiency	Humidity recovery efficiency η_{ERR}	HR efficiency, cooling	Humidity recovery efficiency η_{ERR}	Specific electric power	Air flow range		External pressure	Fittings Dp_{extern}	Frost protection necessary	Noise protection			Additional info
		%	%	%	%	Wh/m³	m³/h	m³/h	Pa	Pa		35 dB(A)	Supply air dB(A)	Exract air dB(A)	
01ud	Heat recovery unit	83%		73%		0.40					yes				
02ud															
03ud															
04ud															
05ud															
06ud															
07ud															
08ud															
09ud															
10ud															
11ud															
12ud															
13ud															

Windows and entrance doors

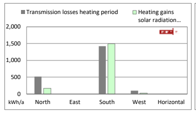
Passive House with PHPP Version 10.3 EN

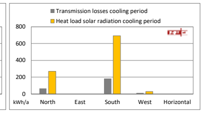
End-of-terrace Passive House / Climate: PHPP-Standard / TFA: 156 m² / Heating: 10.8 kWh/(m²a) / Cooling: 0.1 kWh/(m²a) / PER: 37.4 kWh/(m²a)

Window orientation	Global radiation (main direction)	Shading	Dirt	Non-perpendicular radiation incidence	Glazing fraction	g-value	Solar irradiation reduction factor	Window area	Window U_w installed	Glazing area	Average global radiation
Standard values →	kWh/(m²a)	0.75	0.95	0.85				m²	W/(m²K)	m²	kWh/(m²a)
North	129	0.79	0.95	0.85	0.68	0.50	0.43	11.0	0.71	7.53	129
East	212	1.00	0.95	0.85	0.00	0.00	0.00	0.0	0.00	0.00	212
South	359	0.85	0.95	0.85	0.69	0.50	0.47	30.4	0.71	20.98	359
West	221	0.50	0.95	0.85	0.58	0.50	0.24	2.0	0.73	1.17	221
Horizontal	339	1.00	0.95	0.85	0.00	0.00	0.00	0.0	0.00	0.00	339
Total or average value for all windows.						**0.50**	**0.45**	**43.46**	**0.71**	**29.68**	**296**

	Transmission losses heating period	Heating gains solar radiation heating period
	kWh/a	kWh/a
North	511	163
East	0	0
South	1421	1493
West	96	27
Horizontal	0	0
Total	**2028**	**1682**

	Transmission losses cooling period	Heat load solar radiation cooling period
	kWh/a	kWh/a
North	66	267
East	0	0
South	184	690
West	12	30
Horizontal	0	0
Total	**263**	**987**





Frame absorptivity

Frame emissivity

Heating degree hours [kKh/a]: 66

Cooling degree hours [kKh/a]: 8

Recommendation for $U_{w,\ installed}$		
	Horizontal	1.10
	Inclined	1.00
	Vertical	0.85

Exterior temperature

-15.6 °C

[°C] User-defined

Quantity	Pos. no.	Description	Deviation from north	Angle of inclination from the horizontal	Orientation	Dimensions windows, doors etc.: Width	Height	Installed in: Selection from 'Areas' worksheet	Glazing/panel: Selection list in 'Components' worksheet	Frame: Selection list in 'Components' worksheet	Opening casement: length of outer frame: Left	Right	Top	Bottom	Threshold
			°	°		m	m		1-Sort as list	1-Sort as list	m				
	South façade										0.00	0.00	0.00	0.00	
2	2.01	Floor-to-ceiling, balcony	180	90	South	2.24	2.55	1-External wall south	02ud-Triple-low-e Kr12	01ud-Wooden frame + PU casing	0.00	2.55	1.12	0.00	1.12
2	1.01	Floor-to-ceiling, balcony	180	90	South	2.28	2.12	1-External wall south	02ud-Triple-low-e Kr12	01ud-Wooden frame + PU casing	0.00	2.12	1.14	0.00	1.14
2	0.01	Floor-to-ceiling	180	90	South	2.20	2.12	1-External wall south	02ud-Triple-low-e Kr12	01ud-Wooden frame + PU casing	0.00	2.12	1.10	0.00	1.10
											0.00	0.00	0.00	0.00	
	West façade:										0.00	0.00	0.00	0.00	
1	1.03	Floor-to-ceiling	270	90	West	0.91	2.20	3-External wall west	02ud-Triple-low-e Kr12	01ud-Wooden frame + PU casing	2.20	2.20	0.91	0.00	0.91
											0.00	0.00	0.00	0.00	
	North façade:										0.00	0.00	0.00	0.00	
1	1.02	Floor-to-ceiling, Winter garden	0	90	North	2.40	2.30	2-External wall north	02ud-Triple-low-e Kr12	02ud-Wider wooden frame + PU casing	0.00	2.30	1.20	0.00	1.20
1	2.02	Floor-to-ceiling, Winter garden	0	90	North	2.40	2.30	2-External wall north	02ud-Triple-low-e Kr12	02ud-Wider wooden frame + PU casing	0.00	2.30	1.20	0.00	1.20
											0.00	0.00	0.00	0.00	
											0.00	0.00	0.00	0.00	
											0.00	0.00	0.00	0.00	
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											0.00	0.00	0.00	0.00	
											0.00	0.00	0.00	0.00	
											0.00	0.00	0.00	0.00	

Pos. no.	Fixed glazing: length of outer frame: Left fixed	Right fixed	Top fixed	Bottom fixed	Mullion length: fm	m2	m1	m	Transom length: t2	t1	t	Number of glass carriers	Installation: own value for $\Psi_{installed}$ or 1 = $\Psi_{installed}$ from 'Components' worksheet 0 = adjacent to other window: Left	Right	Top	Bottom	Thermal parameters: U_f frame (mean)	g-value glazing	U_g glazing	$\Psi_{Glazing\ edge}$	$\Psi_{Installation}$ (Avg.)	Results: Window area	Glazing area	Glazing fraction per window	U_w	U_w installed	EnerPHit	Window surface temperature assessment: Comfort		Heat gains heating period	Heat loads cooling period
	m				m				m			Pieces	W/(mK) or 1/0				W/(m²K)	-	W/(m²K)	W/(mK)	W/(mK)	m²	m²	%	W/(m²K)	W/(m²K)	Exemption	Exemption		kWh/a	kWh/a
South façade													1	1	1	1															
2.01	2.55		1.12	1.12			2.55						1	1	1	1	0.60	0.50	0.58	0.049	0.009	**11.4**	**8.0**	**70%**	**0.694**	**0.708**				67	204
1.01	2.12		1.14	1.14			2.12						1	1	1	1	0.60	0.50	0.58	0.049	0.009	**9.7**	**6.6**	**69%**	**0.698**	**0.714**				18	157
0.01	2.12		1.10	1.10			2.12						1	1	1	1	0.60	0.50	0.58	0.049	0.009	**9.3**	**6.3**	**68%**	**0.700**	**0.716**				-13	145
													1	1	1	1															
West façade:													1	1	1	1															
1.03													1	1	1	1	0.60	0.50	0.58	0.049	0.007	**2.0**	**1.2**	**58%**	**0.710**	**0.732**				-70	18
													1	1	1	1															
North façade:													1	1	1	1															
1.02	2.30		1.20	1.20		2.30							1	1	1	1	0.60	0.50	0.58	0.049	0.009	**5.5**	**3.8**	**68%**	**0.691**	**0.706**				-166	112
2.02	2.30		1.20	1.20		2.30							1	1	1	1	0.60	0.50	0.58	0.049	0.009	**5.5**	**3.8**	**68%**	**0.691**	**0.706**				-182	89
													1	1	1	1															
													1	1	1	1															
													1	1	1	1															
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Calculation of reduction factors for shading

End-of-terrace Passive House / Climate: PHPP-Standard / TFA: 156 m² / Heating: 10.8 kWh/(m²a) / Cooling: 0.1 kWh/(m²a) / PER: 37.4 kWh/(m²a)

Latitude: 51.3 °

Orientation	Glazing area [m²]	Reduction factor winter r_v	Reduction factor cooling $r_{v,1}$	Reduction factor cooling load $r_{v,2}$	Solar load [kWh/(m²$_{Glazing}$a)]
North	7.53	79%	84%	84%	28
East	0.00	100%	100%	100%	0
South	20.98	85%	46%	36%	28
West	1.17	50%	39%	30%	21
Horizontal	0.00	100%	100%	100%	0

								Horizon		Lateral reveal		Reveal / Overhang					Reduction factors for shading in winter				Reduction factors for shading in summer				
Quan-tity	Description	Deviation from North	Angle of inclination from the horizontal	Orientation	Glazing width	Glazing height	Glazing area	Height of the shading object	Distance of horizon	Window reveal depth	Distance from glazing edge to reveal	Overhang depth	Distance from upper glazing edge to overhang	Additional shading reduction factor, winter	Additional shading reduction factor, summer	Reduction factor z for temporary sun protection	Regulated / transparent	Horizon	Reveal	Overhang	Total for winter	Horizon	Reveal	Overhang	Total for summer	Total for cooling load
		[Degrees]	[Degrees]		w_G [m]	h_G [m]	A_G [m²]	h_{Hori} [m]	d_{Hori} [m]	o_{Reveal} [m]	d_{Reveal} [m]	o_{over} [m]	d_{over} [m]	$r_{other,w}$ [%]	$r_{other,s}$ [%]	z [%]		r_H [%]	r_R [%]	r_O [%]	r_S [%]	r_H [%]	r_R [%]	r_O [%]	$r_{S,1}$ [%]	$r_{S,2}$ [%]
	South façade																									
2	2.01 Floor-to-ceiling, balcony	180	90	South	1.97	2.24	8.0	5.80	42.50	0.23	0.000	0.23	0.00			37%		96%	95%	98%	89%	95%	94%	96%	48%	37%
2	1.01 Floor-to-ceiling, balcony	180	90	South	2.01	1.81	6.6	8.30	42.50	0.23	0.000	0.23	0.00			37%		92%	95%	97%	85%	93%	94%	94%	46%	36%
2	0.01 Floor-to-ceiling	180	90	South	1.93	1.81	6.3	10.80	42.50	0.23	0.000	0.23	0.00			37%		87%	95%	97%	80%	91%	93%	94%	45%	35%
	West façade:																									
1	1.03 Floor-to-ceiling	270	90	West	0.62	1.88	1.2	16.00	50.00	0.23	0.000	0.23	0.00			37%		74%	73%	93%	50%	80%	89%	98%	39%	30%
	North façade:																									
1	1.02 Floor-to-ceiling, Winter gar	0	90	North	2.10	1.98	3.8	0.20	12.00	0.23	0.000	0.23	0.00					99%	94%	93%	86%	99%	94%	98%	91%	91%
1	2.02 Floor-to-ceiling, Winter gar	0	90	North	2.10	1.98	3.8	3.00	12.00	0.23	0.000	0.23	0.00					81%	94%	93%	71%	82%	94%	98%	76%	76%

Ventilation data

End-of-terrace Passive House / Climate: PHPP-Standard / TFA: 156 m² / Heating: 10.8 kWh/(m²a) / Cooling: 0.1 kWh/(m²a) / PER: 37.4 kWh/(m²a)

Treated floor area A_{TFA}		156	m²			
Room height h		2.50	m	Used	2.50	m
Volume of ventilated space (A_{TFA}*h) =	V_V	390	m³			

Selection of ventilation input

Type of ventilation	1-Balanced PH ventilation with HR	
'Ventilation' worksheet	x	Standard project design for residential buildings
'Addl vent' worksheet		Multiple ventilation units, non-res

Infiltration air change rate

			For annual demand:	For heating load:	
Wind protection coefficient, e	2-Moderate protection		0.07	0.18	
Wind protection coefficient, f			15	15	
Net air volume for pressurisation test		V_{n50}	480		m³
Air change rate from pressurisation test		n_{50}	0		1/h
Air permeability		q_{50}	0.37		m³/(hm²)
			For annual demand:	For heating load:	
Excess extract air			0.00	0.00	1/h
Infiltration air change rate		$n_{V,Rest}$	0.026	0.065	1/h

Results

Average airflow rate	Average air change rate heating period	Excess air (extract air system)	Effective heat recovery efficiency, unit	Humidity recovery efficiency	Heat recovery efficiency, cooling	Humidity recovery efficiency	Specific electric efficiency	SHX Heat recovery efficiency
m³/h	1/h	1/h	[-]	[-]	[-]	[-]	Wh/m³	[-]
117	**0.30**	**0.00**	**82.0%**	**N/A**	**72.0%**	**N/A**	**0.40**	**31.3%**

Transfer		Efficiency SHX
	η^*_{SHX}	93%

Average interior humidity during winter operation

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
36%	36%	41%	-	-	-	-	-	-	-	43%	39%

Summary: multiple ventilation units, non-res

The 'Addl vent' and 'Addl vent 2' worksheets (unhide if required) can be used to enter up to 10 different ventilation units each (if more units are used, please click on the + symbol on the left).

Worksheet name	Annual average values V_{SUP} m³/h	V_{ETA} m³/h	Air ch.rt. 1/h	Effective heat recovery efficiency, unit	Humidity recovery efficiency	Heat recovery efficiency, cooling	Humidity recovery efficiency	Specific electric efficiency	SHX heat recovery efficiency	Useful energy electric frost protection	Useful energy hydraulic frost protection
('Addl vent' worksheet)										53	0
('Addl vent 2' worksheet)									0%	0	0
Total / Average values											

Ventilation data

Passive House with PHPP Version 10.3 EN

Dimensioning of a ventilation system with only one ventilation unit

Occupant density	m²/P	53				
Number of occupants	P	2.9				
Supply air per person	m³/(P*h)	30				
Supply air demand	m³/h	**88**		Bathroom		
Extract air rooms		Kitchen	Bathroom	(shower only)	WC	
Quantity		1	1	1	1	
Extract air demand per room	m³/h	60	40	20	20	
Total extract air demand	m³/h	**140**				

Design airflow rate (maximum) m³/h 152 Recommended: 152 m³/h

Calculation of the average air change rate

Type of operation	Daily operation hours h/d	Factors referenced to maximum	Airflow rate m³/h	Air change rate 1/h
Maximum		1.00	152	0.39
Standard	24.0	0.77	117	0.30
Basic ventilation		0.54	82	0.21
Minimum		0.40	61	0.16
			Average airflow rate (m³/h)	Average air change rate (1/h)
Average value		0.77	**117**	**0.30**

Selection of ventilation unit with heat recovery

Location of ventilation unit: 1-Inside thermal envelope

Selection of ventilation unit	Go to ventilation units list / 1-Sort as list	$T_{room} > T_{outdoor}$ Heat recovery efficiency Unit η_{HR}	$T_{room} > T_{outdoor}$ Energy recovery efficiency	$T_{room} < T_{outdoor}$ Cool recovery rate Unit η_{HR}	$T_{room} < T_{outdoor}$ Energy recovery efficiency	Specific power input [Wh/m³]	Airflow range [m³/h]	Frost protection necessary
	01ud-HRV	0.83	N/A	0.73	N/A	0.40	N/A	yes

Conductivity of outdoor air duct	Ψ	W/(mK)	0.165
Length of outdoor air duct		m	1.1
Conductivity of outdoor air duct	Ψ	W/(mK)	0.226
Length of exhaust air duct		m	1.5
Temperature of mechanical room (enter only if the unit is outside of the thermal envelope)		°C	11

HR efficiency, cooling: 0.72

Implementation of frost protection	2-Electr.
Limit temperature [°C]	-3
Useful energy [kWh/a]	0
Room temperature (°C)	20
Avg. ambient temp. heating period (°C)	4.9
Avg. ground temp (°C)	10.0

Effective heat recovery efficiency $\eta_{HR,eff}$ **82.0%**

Effective heat recovery efficiency subsoil heat exchanger

SHX efficiency	η^*_{SHX}	93%
Heat recovery efficiency SHX	η_{SHX}	31%

Secondary calculation
Ψ-value supply or outdoor air duct

Nominal width:	100	mm
Insulation thickness:	150	mm
Aluminium laminated?	x	
Thermal conductivity	0.040	W/(mK)
Nominal airflow rate	117	m³/h
Δϑ	15	K
Exterior duct diameter	0.100	m
Exterior diameter	0.400	m
α–Interior	19.01	W/(m²K)
α-Surface	2.07	W/(m²K)
Ψ–value	**0.165**	**W/(mK)**
Surface temperature difference	0.954	K

Secondary calculation
Ψ-value extract or exhaust air duct

Nominal width:	125	mm
Insulation thickness:	100	mm
Aluminium laminated?	x	
Thermal conductivity	0.040	W/(mK)
Nominal airflow rate	117	m³/h
Δϑ	15	K
Exterior duct diameter	0.125	m
Exterior diameter	0.325	m
α–Interior	12.72	W/(m²K)
α-Surface	2.31	W/(m²K)
Ψ–value	**0.226**	**W/(mK)**
Surface temperature difference	1.445	K

Extended input for balanced ventilation (at the moment this worksheet is inactive. Calculation takes place in the 'Ventilation' worksheet.)

End-of-terrace Passive House / Climate: PHPP-Standard / TFA: 156 m² / Heating: 10.8 kWh/(m²a) / Cooling: 0.1 kWh/(m²a) / PER: 37.4 kWh/(m²a)

Planning ventilation systems with multiple ventilation units

Ventilation unit / Effective heat recovery efficiency

x	Standard project design ('Ventilation' worksheet)
	Multiple ventilation units, non-res (this worksheet)

Treated floor area A_{TFA}	156	m²	('Areas' worksheet)
Room height h	2.50	m	('Ventilation' worksheet)
Volume of ventilated space (A_{TFA}*h) = V_V	390	m³	('Annual heating' worksheet)
Number of occupants	2.9	P	('Verification' worksheet)
Interior temperature	20	°C	('Annual heating' worksheet)
Average ambient temp. heating period	4.9	°C	('Ventilation' worksheet)
Average ground temperature	10.0	°C	('Ground' worksheet)
Length of the heating period	219	d/a	('Heating' worksheet)
Ventilation type	1-Balanced PH ventilation with HR		('Ventilation' worksheet)

Results of ventilation design and unit selection:

Venti-lation unit No.	Description of the unit	Design V_{SUP} m³/h	Design V_{ETA} m³/h	Annual average values V_{SUP} m³/h	Annual average values V_{ETA} m³/h	ACH 1/h	$T_{room} > T_{outdoor}$ Effective heat recovery efficiency	$T_{room} > T_{outdoor}$ Humidity recovery efficiency	$T_{room} < T_{outdoor}$ HR efficiency, cooling	$T_{room} < T_{outdoor}$ Humidity recovery efficiency	Specific electric efficiency	SHX heat recovery efficiency
1	Unit 1	152	152	117	117	---	82%	N/A	72%	N/A	0.40	0%
2						---						
3						---						
4						---						
5						---						
6						---						
7						---						
8						---						
9						---						
10						---						
Overall results vent. system												

Recommendations for dimensioning air quantities

Use building materials/furnishings with low odour and low VOCs
It is strongly recommended to use building materials that cause very low or no VOCs/odours instead of increasing the outdoor air volume in order to clear the air.
This holds true regardless of the chosen approach to determine air quality; emissions of all sources in the room should be considered, e.g. furniture, carpets and ventilation or air-conditioning units themselves.

Assessment of airflow rates according to the number of persons
Also in non-residential buildings, the number of persons is fundamentally important for assessing the airflow rates. For good indoor air quality, airflow rates between 20 to 30 m3/(h*P) are sufficient.
Greater airflow rates can lead to indoor air that is too dry in winter. The airflow rates are defined by the classification according to the EN 13779 norm. The classification must be agreed with the client in advance.
IDA 3 is adequate for office buildings. IDA 4 has proven to be satisfactory for school buildings, as flushing ventilation is carried out during breaks anyway. For typical outdoor air CO_2 concentrations of around 400-500 ppm, it is possible to comply even with 1500 ppm. Exceeding this figure temporarily is permissible.

Outdoor airflow rates per person:
- Recommended for residential buildings: around 30 m³/h per person
- Recommendation for office-like uses: around 30 m³ /h per person (AMEV: 28 m³ / (h person); EN 13779 / IDA 3: at least 24 m³ /h per person)
- Recommended for schools and day care centres: 15 to 20 m³/h per person (Source: Guidelines for energy-efficient educational buildings, Passive House Institute, 2010)
- Recommendation for sport halls: 60 m³/h per person (DIN 18032-1)

Flushing phase for intermittent operation
In case the ventilation is used intermittently (turned off at night), then the air in the room should be flushed in the morning during approx. 1 or 2 hours before the building is occupied, 'and in order to eliminate emissions released during the night. The flushing phase increases the operating period of the ventilation system (utilisation time + flushing phase). Please consider this during the design stage.

Dimensioning of air quantities

When dimensioning the air quantities, please consider the design recommendations given above.
The operation period of the ventilation system can be determined on the basis of the daily utilisation hours including the flushing phase.
Periods with a lower air demand (operation modes) can be taken into account by means of reduction factors.

Room no.	Quantity q	Room name	Allocation to ventilation unit (No.)	Area A m²	Clear height h m	Room vol. A x h m³	Volume flow per room V_{SUP} m³/h	V_{ETA} m³/h	V_{TRANS} m³/h	ACH per room n 1/h	Utilisation period h/d h	d/week d	Duration of holidays d	Reduction factor 1	Operation red. 1	Reduction factor 2	Operation red. 2	Reduction factor 3	Operation red. 3	Annual average value: V_{SUP} m³/h	V_{ETA} m³/h	V_{TRANS} m³/h	ACH 1/h
1	1	Dwelling unit	1	156	2.70	421	152	152		0.36	24	7		77%	100%					117	117		0.28
2														100%	100%								
3														100%	100%								
4														100%	100%								
5														100%	100%								
6														100%	100%								
7														100%	100%								
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	Additional rows: please select full rows above, and copy and instert them multiple times.																			117	117	---	0.28

Selection of the ventilation unit

Up to 10 different ventilation units can be considered. Identical units can be considered by changing the quantity. The data from ventilation units certified by the Passive House Institute can be found in the 'Components' worksheet together with the entry of user-defined data. If compact units are used, then standard project planning in the worksheet "Ventilation" should be used.

Go to list of ventilation units

															$T_{room} > T_{outdoor}$			$T_{room} < T_{outdoor}$								
Venti-lation unit no.	Quan-tity [-]	Description of ventilation units	Selection of ventilation unit	Design air flow rate per unit m³/h	Application range air flow rate from m³/h	to m³/h	Specific electric efficiency Wh/m³	Pressure loss calculation ODA-SUP Δp_{Duct} Pa	ETA-EHA Δp_{Duct} Pa	Additional Δp_{Intern} Pa	Application range per line $\Delta p_{External}$ Pa	Subtraction Δp_{Intern} Pa	Interior location (x)	Exterior location (x)	Heat recovery efficiency Unit [-]	Effective [-]	Humidity recovery efficiency [-]	HR efficiency, cooling [-]	Humidity recovery efficiency [-]	Frost protection necessary	Subsoil HX Heat recovery efficiency	Effective HR efficiency	Frost protection (electr. / hydr.) Execution	Limit temperature °C	Useful energy kWh/a
			Sorting options																							
1	1	Unit 1	01ud-HRV	152	N/A	N/A	0.40	100	100		-	-		x	0.83	**82%**	N/A	0.73	N/A	yes		0%	2-Elec.	-3	53
2																									0
3																									0
4																									0
5																									0
6																									0
7																									0
8																									0
9																									0
10																									0
																								Total (direct electric)	53
																								Total (hydraulic via heat generator)	0

Data entries for duct sections between the ventilation unit and the thermal envelope

The duct sections between the ventilation unit and the thermal envelope should be as short as possible and should be well insulated, whether the ventilation unit is located indoors or outdoors. The dimensions of these duct sections can be entered here. The heat losses are considered through the effective heat recovery in the section above.
One section of a duct entered here may also be used for multiple ventilation units.
If a ventilation unit is considered more than once in a given row (quantity >1 for identical units) in the section "Selection of the ventilation unit", the ducts corresponding to this unit should be entered once (duct sections for one ventilation unit).

Temperature of installation room: 11.0 (only enter when at least one unit is installed outside of the thermal envelope)

Quan-tity	Round duct diameter mm	Rectangular duct width mm	Height mm	Insulation thickness mm	Thermal conducti-vity W/(m K)	Reflective aluminum laminated? (x)	Conduc-tance duct W/(m K)	Length of supply air duct m	Outdoor or supply air duct (1)	Exhaust or extract air duct (1)	Duct type	Design air flow rate	Assignment to ventilation unit (enter 1 for the corresponding ventilation unit) vent. unit 1	vent. unit 2	vent. unit 3	vent. unit 4	vent. unit 5	vent. unit 6	vent. unit 7	vent. unit 8	vent. unit 9	vent. unit 10
1	100			150	0.04	x	**0.164**	1.1	1		SUP	152	1									
1	125			100	0.04	x	**0.223**	1.5		1	ETA	152	1									
												0										
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Specific energy demand for heating (annual method)

Passive House with PHPP Version 10.3 EN

End-of-terrace Passive House / Climate: PHPP-Standard / TFA: 156 m² / Heating: 10.8 kWh/(m²a) / Cooling: 0.1 kWh/(m²a) / PER: 37.4 kWh/(m²a)

Interior temperature:	20.0	°C
Building type:	4-Row house	
Treated floor area A_{TFA}:	156.0	m²

Transmission heat losses Q_T

Building assembly	Temperature zone	Area m²		U-value W/(m²K)		Temperature reduction factor		G_t kKh/a		kWh/a	Per m² of TFA
External wall - ambient	A	184.3	*	0.118	*	1.00	*	81.9	=	1786	11.45
External wall ground/basement	B		*		*	0.57	*		=		
Roof / ceiling - ambient	A	83.4	*	0.108	*	1.00	*	81.9	=	735	4.71
Floor slab / basement ceiling	B	80.9	*	0.185	*	0.57	*	81.9	=	696	4.46
	A		*		*	1.00	*		=		
	A		*		*	1.00	*		=		
	A		*		*	1.00	*		=		
Windows	A	43.5	*	0.712	*	1.00	*	81.9	=	2534	16.24
Exterior door	A		*		*	1.00	*		=		
Thermal bridges ambient (length/m)	A	122.9	*	-0.024	*	1.00	*	81.9	=	-237	-1.52
Perimeter thermal bridges (length/m)	P		*		*	0.57	*		=		0.00
Thermal bridges ground (length/m)	B	11.4	*	0.061	*	0.57	*	81.9	=	32	0.21
										kWh/a	kWh/(m²a)
Sum of all areas of the building envelope		392.1				**Total transmission heat losses Q_T**			=	**5546**	**35.6**

Ventilation heat losses Q_V

		m²		m		m³
Volume of ventilated space, V_V (A_{TFA}*h)		156.0	*	2.50	=	390.0
Ventilation system:						
Effective heat recovery efficiency of the heat exchanger	η_{eff}	82%				
Heat recovery efficiency of SHX	η_{SHX}	31%				

	$n_{V,system}$ 1/h		η_{HR}		$n_{V,Res}$ 1/h		1/h
Energetically effective air changes nV	0.300	* (1 -	0.88	) +	0.026	=	0.063

	V_V m³		n_V 1/h		c_{Air} Wh/(m³K)		G_t kKh/a		kWh/a	kWh/(m²a)
Total ventilation heat losses Q_V	390.0	*	0.063	*	0.33	*	81.9	=	**663**	**4.2**

		Q_T kWh/a		Q_V kWh/a		Reduction factor night/weekend lowering	=	kWh/a	kWh/(m²a)
Total heat losses Q_L	(	5546	+	663	)	1.0	=	**6209**	**39.8**

Available solar heat gains Q_S

Orientation of the area	Reduction factor See 'Windows' worksheet		g-value (perp. radiation)		Area m²		Global radiation heating period kWh/(m²a)		kWh/a
North	0.43	*	0.50	*	11.04	*	129	=	310
East	0.00	*	0.00	*	0.00	*	212	=	0
South	0.47	*	0.50	*	30.42	*	359	=	2592
West	0.24	*	0.50	*	2.00	*	221	=	53
Horizontal	0.00	*	0.00	*	0.00	*	339	=	0
									kWh/(m²a)
							Total available solar heat gains Q_S	=	**2954**	**18.9**

Internal heat gains Q_I

		Length heating period		Spec. power q_I		A_{TFA}		
	kh/d	d/a		W/m²		m²	kWh/a	kWh/(m²a)
	0.024	219	*	2.42	*	156.0	**1984**	**12.7**

Utilisation factor heat gains η_G

			kWh/a	kWh/(m²a)
Free heat Q_F	Q_S + Q_I	=	4938	31.7
Ratio of free heat to losses	Q_F / Q_L	=	0.80	
Utilisation factor heat gains h_G	(1 - (Q_F / Q_L)^5) / (1 - (Q_F / Q_L)^6)	=	**91%**	
Total heat gains Q_G	η_G * Q_F	=	**4507**	**28.9**
			kWh/a	kWh/(m²a)

Annual heating demand Q_H

			kWh/a	kWh/(m²a)
	Q_L - Q_G	=	**1702**	**10.9**

	kWh/(m²a)		
Limit value	15	**Requirement met?**	**Yes**

Specific energy demand for heating (monthly method)

Passive House with PHPP Version 10.3 EN

End-of-terrace Passive House / Climate: PHPP-Standard / TFA: 156 m² / Heating: 10.8 kWh/(m²a) / Cooling: 0.1 kWh/(m²a) / PER: 37.4 kWh/(m²a)

The sum of the heating periods calculated through the monthly method is presented on this worksheet.

Interior temperature:	20	°C
Building type:	4-Row house	
Treated floor area A_{TFA}:	156.0	m²
Spec. Capacity:	204	Wh/(m²K)

Transmission heat losses Q_T

Building assembly	Temperature zone	Area m²		U-value W/(m²K)		Temperature reduction factor		G_t kKh/a		kWh/a	Per m² of TFA
External wall - ambient	A	184.3	*	0.118	*	1.00	*	66	=	1430	9.16
External wall ground/basement	B		*		*	1.00	*		=		
Roof / ceiling - ambient	A	83.4	*	0.108	*	1.00	*	66	=	588	3.77
Floor slab / basement ceiling	B	80.9	*	0.185	*	1.00	*	31	=	466	2.99
	A		*		*	1.00	*		=		
	A		*		*	1.00	*		=		
	A		*		*	1.00	*		=		
Windows	A	43.5	*	0.712	*	1.00	*	66	=	2028	13.00
Exterior door	A		*		*	1.00	*		=		
Thermal bridges ambient (length/m)	A	122.9	*	-0.024	*	1.00	*	66	=	-190	-1.22
Perimeter thermal bridges (length/m)	P		*		*	1.00	*		=		0.00
Thermal bridges ground (length/m)	B	11.4	*	0.061	*	1.00	*	31	=	22	0.14
											kWh/(m²a)
Sum of all areas of the building envelope		392.1				**Total transmission heat losses Q_T**			=	**4343**	**27.8**

Ventilation heat losses Q_V

					m²		m		m³	
Volume of ventilated space, V_V (A_{TFA}*h)					156	*	2.50	=	390	
	$n_{V,system}$ 1/h		η*SHX		η_{HR}		$n_{V,Res}$ 1/h		$n_{V,equi,fraction}$ 1/h	
Effective air change rate Ambient $n_{V,e}$	0.300	*(1-	93%	)*(1-	0.82	)+	0.026	=	0.030	
Effective air change rate Ground $n_{V,g}$	0.300	*	93%	*(1-	0.82	)		=	0.050	
	V_V m³		$n_{V,equi,fraction}$ 1/h		c_{Air} Wh/(m³K)		G_t kKh/a		kWh/a	kWh/(m²a)
Ventilation losses ambient Q_V	390	*	0.030	*	0.33	*	66	=	250	1.6
Ventilation losses ground $Q_{V,e}$	390	*	0.050	*	0.33	*	36	=	234	1.5
					Total ventilation heat losses Q_V			=	**484**	**3.1**

Total heat losses Q_L	(	4343	+	484	)	*	1.0	=	4827	**30.9**
		Q_T kWh/a		Q_V kWh/a			Reduction factor night/weekend lowering		kWh/a	kWh/(m²a)

Available solar heat gains Q_S

Orientation of the area	Reduction factor see 'Windows' worksheet		g-value (perp. radiation)		Area m²		Global radiation kWh/(m²a)		kWh/a
North	0.43	*	0.50	*	11.0	*	68	=	163
East	0.00	*	0.00	*	0.0	*	104	=	0
South	0.47	*	0.50	*	30.4	*	207	=	1493
West	0.24	*	0.50	*	2.0	*	112	=	27
Horizontal	0.00	*	0.00	*	0.0	*	164	=	0
Sum opaque areas									104
									kWh/(m²a)
					Total available solar heat gains Q_S			=	**1787**	**11.5**

Internal heat gains Q_I

		Length Heat. Period d/a		Spec. Power q_I W/m²		A_{TFA} m²		kWh/a	kWh/(m²a)
	kh/d								
	0.024	151	*	2.4	*	156.0	=	**1368**	**8.8**

Utilisation factor heat gains η_G

			kWh/a	kWh/(m²a)
Free heat Q_F	Q_S + Q_I	=	3155	20.2
Ratio free heat to losses	Q_F / Q_L	=	0.65	
Utilisation factor heat gains h_G		=	100%	
Total heat gains Q_G	η_G * Q_F	=	3140	**20.1**
			kWh/a	kWh/(m²a)

			kWh/a	kWh/(m²a)
Annual heating demand Q_H	Q_L - Q_G	=	1687	**10.8**

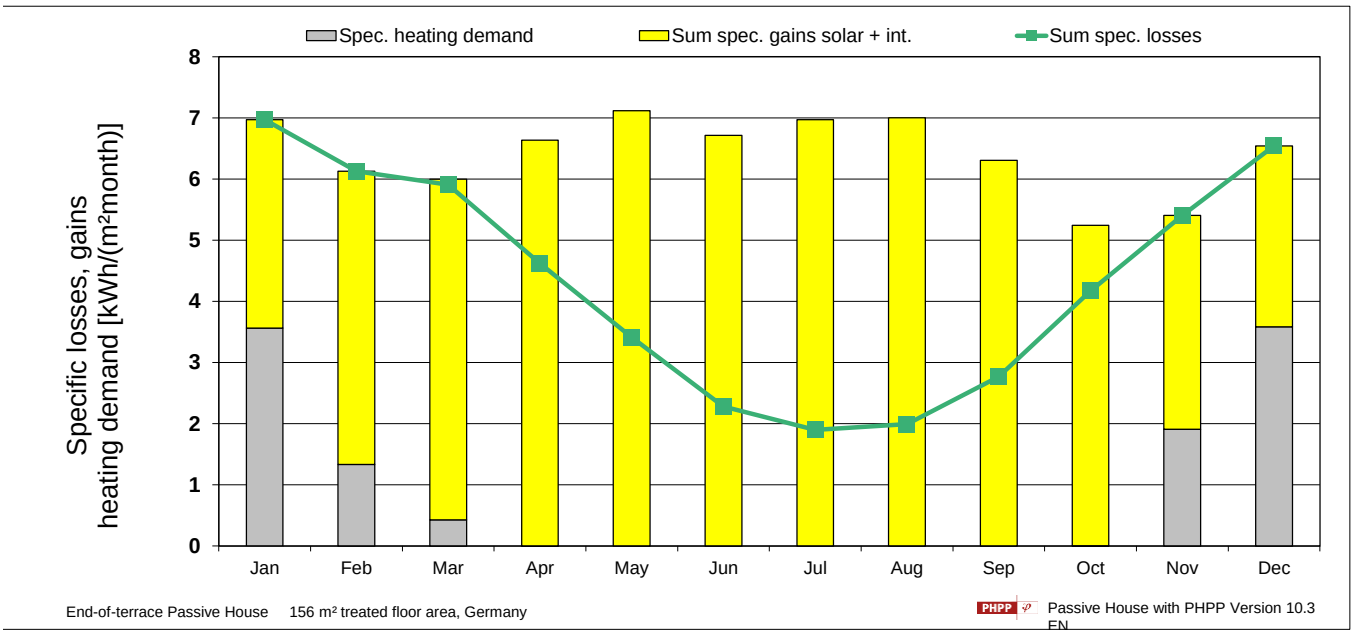
	kWh/(m²*a)		
Limit value	15	**Requirement met?**	**Yes**

Specific energy for heating (monthly method)

End-of-terrace Passive House / Climate: PHPP-Standard / TFA: 156 m² / Heating: 10.8 kWh/(m²a) / Cooling: 0.1 kWh/(m²a) / PER: 37.4 kWh/(m²a)

Interior temperature:	20	°C
Building type:	4-Row house	
Treated floor area A_{TFA}:	156	m²

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	
Heating degree hours - exterior	15.0	13.0	12.0	8.8	5.7	3.0	2.1	2.5	4.7	8.2	11.4	14.1	100	kKh
Heating degree hours - ground	6.2	6.2	7.6	7.8	8.2	7.8	7.5	6.8	6.0	5.7	5.3	5.7	81	kKh
Losses - exterior	941	814	754	551	355	187	130	156	292	514	713	882	6290	kWh
Losses - ground	146	141	167	169	177	168	166	155	140	137	130	138	1835	kWh
Sum spec. losses	7.0	6.1	5.9	4.6	3.4	2.3	1.9	2.0	2.8	4.2	5.4	6.5	52.1	kWh/m²
Solar gains - North	24	36	62	89	120	132	132	105	72	43	24	17	855	kWh
Solar gains - East	0	0	0	0	0	0	0	0	0	0	0	0	0	kWh
Solar gains - South	209	425	476	598	613	548	577	620	577	454	231	151	5480	kWh
Solar gains - West	3	7	10	16	19	19	20	17	13	8	4	2	139	kWh
Solar gains - Horiz.	0	0	0	0	0	0	0	0	0	0	0	0	0	kWh
Solar gains - Opaque	14	26	39	60	77	77	78	69	50	31	15	10	547	kWh
Internal heat gains	281	254	281	272	281	272	281	281	272	281	272	281	3308	kWh
Sum spec. gains solar + int.	3.4	4.8	5.6	6.6	7.1	6.7	7.0	7.0	6.3	5.2	3.5	3.0	66.2	kWh/m²
Utilisation factor	100%	100%	98%	70%	48%	34%	27%	28%	44%	80%	100%	100%	62%	
Annual heating demand	556	208	66	0	0	0	0	0	0	0	298	559	1687	kWh
Spec. heating demand	**3.6**	**1.3**	**0.4**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**1.9**	**3.6**	**10.8**	kWh/m²



Annual heating demand: Comparison

Monthly method	*('Heating')*	**1687**	**kWh/a**	**10.8**	**kWh/(m²a)** reference to treated floor area according to PHPP
Annual method	*('Annual heating')*	**1702**	**kWh/a**	**10.9**	**kWh/(m²a)** reference to treated floor area according to PHPP

Heating load

End-of-terrace Passive House / Climate: PHPP-Standard / TFA: 156 m² / Heating: 10.8 kWh/(m²a) / Cooling: 0.1 kWh/(m²a) / PER: 37.4 kWh/(m²a)

Interior temperature:	20	°C
Building type:	4-Row house	
Treated floor area A_{TFA}:	156.0	m²

	Design temperature		Radiation:	North	East	South	West	Horizontal	
Weather 1:	-10.6	°C		10	30	90	35	40	W/m²
Weather 2:	-1.2	°C		5	5	10	5	10	W/m²
Ground design temp.	12.3	°C							

Transmission heat load P_T

Building assembly	Temperature zone	Area m²		U-value W/(m²K)		Thermal reduction factor		Temp Diff 1 K		Temp Diff 2 K		PT 1 W		PT 2 W
External wall - ambient	A	184.3	*	0.118	*	1.00	*	30.6	or	21.2	=	666	or	463
External wall ground/basement	B		*		*	1.00	*	7.7	or	7.7	=		or	
Roof / ceiling - ambient	A	83.4	*	0.108	*	1.00	*	30.6	or	21.2	=	274	or	191
Floor slab / basement ceiling	B	80.9	*	0.185	*	1.00	*	7.7	or	7.7	=	115	or	115
	A		*		*	1.00	*	30.6	or	21.2	=		or	
	A		*		*	1.00	*	30.6	or	21.2	=		or	
	A		*		*	1.00	*	30.6	or	21.2	=		or	
Windows	A	43.5	*	0.712	*	1.00	*	30.6	or	21.2	=	945	or	657
Exterior door	A		*		*	1.00	*	30.6	or	21.2	=		or	
Thermal bridges ambient (length/m)	A	122.9	*	-0.024	*	1.00	*	30.6	or	21.2	=	-88	or	-62
Perimeter thermal bridges (length/m)	P		*		*	1.00	*	7.7	or	7.7	=		or	
Thermal bridges ground (length/m)	B	11.4	*	0.061	*	1.00	*	7.7	or	7.7	=	5	or	5
Building element towards neighbour	I	100.9	*	0.375	*	1.00	*	3.0	or	3.0	=	114	or	114
										Total	=	**2032**	or	**1484**

Ventilation heat load P_V

		m²		m		m³
Volume of ventilated space, V_V (A_{TFA}*h)		156.0	*	2.50	=	390.0

Ventilation system:

					$\eta_{SHX\,1}$		$\eta_{SHX\,2}$
Heat recovery efficiency of the heat exchanger	η_{HR} 82%	Efficiency of SHX	93%	Heat recovery efficiency SHX	63%	or	49%

	$n_{V,Res}$ (Heating Load) 1/h		$n_{V,system}$ 1/h		Φ_{HP}		Φ_{HP}		1/h		1/h
Energetically effective air changes n_V	0.065	+	0.300	*(1-	0.93	or	0.91	) =	0.085	or	0.092

V_V m³		n_V 1/h		n_V 1/h		c_{Air} Wh/(m³K)		TempDiff 1 K		TempDiff 2 K		P_V 1 W		P_V 2 W
390.0	*	0.085	or	0.092	*	0.33	*	30.6	or	21.2	=	**334**	or	**252**

Total heat load P_L

		PL 1 W		PL 2 W
$P_T + P_V$	=	**2365**	or	**1735**

Solar heat power P_S

Orientation of the area	Area m²		g-value (perp. radiation)		Reduction factor (see 'Windows' worksheet)		Radiation 1 W/m²		Radiation 2 W/m²		P_T 1 W		P_T 2 W
North	11.0	*	0.5	*	0.43	*	10	or	5	=	24	or	12
East	0.0	*	0.0	*	0.40	*	30	or	5	=	0	or	0
South	30.4	*	0.5	*	0.47	*	90	or	10	=	649	or	72
West	2.0	*	0.5	*	0.24	*	35	or	5	=	8	or	1
Horizontal	0.0	*	0.0	*	0.40	*	40	or	10	=	0	or	0
									Total solar heat power P_S	=	**681**	or	**85**

Internal heat load P_I

Spec. power W/m²		A_{TFA} m²		P_I 1 W		P_I 2 W
1.9	*	156	=	**300**	or	**300**

Total heat power (gains) P_G

		P_G 1 W		P_G 2 W
$P_S + P_I$	=	**981**	or	**385**

Heating load P_H

$P_L - P_G$	=	1384	or	1350
Heating load P_H	=		**1384**	**W**
Area specific space heating load P_H / A_{TFA}	=		**8.9**	**W/m²**

For comparison: heat load via supply air

Input max. supply air temperature	52	°C
Max. supply air temperature $\vartheta_{Supply,Max}$	52	°C

		°C		°C
Supply air temperature without heating $\vartheta_{Supply,Min}$	=	17.9		18.1
Heating load that can be transported by the supply air $P_{Supply;Max}$	=		**1314**	W
$P_{Supply;Max}$ / A_{TFA}	=		**8.4**	W/m²
Heating via supply air?			**No**	

Summer ventilation

End-of-terrace Passive House / Climate: PHPP-Standard / TFA: 156 m² / Heating: 10.8 kWh/(m²a) / Cooling: 0.1 kWh/(m²a) / PER: 37.4 kWh/(m²a)

Building volume:	390	m³	Building type:	4-Row house	
Max. indoor absolute humidity:	12	g/kg	Heat recovery efficiency:	82%	
Internal humidity sources:	100	g/(P*h)	Humidity recovery efficiency η_{EER}:	0%	
			Subsoil heat exchanger efficiency η^*_{SHX}:	93%	

Basic ventilation to ensure adequate air quality (summer)

Air change via vent. system with supply air: 0.30 1/h

HRV/ERV in summer (check only one field)

None	x
Automatic bypass, controlled by temperature difference	
Automatic bypass, controlled by enthalpy difference	
Always	

Air change rate via extract air system: 0.00 1/h

Specific power consumption (for extract air system): 0.00 Wh/m³

Window ventilation air change rate: 0.35 1/h

Effective air change rate

	$n_{V,system}$ 1/h		η^*_{SHX}		η_{HR}		$n_{V,equi,fraction}$ 1/h	
Exterior $n_{V,e}$	0.300	*(1-	93%	)*(1-	0.82	) =	0.004	
without HR	0.300	*(1-	93%	)		=	0.021	
Ground $n_{L,g}$	0.300	*	93%	*(1-	0.82	) =	0.050	
without HR	0.300	*	93%			=	0.279	

Ventilation conductance

	V_V m³		$n_{V,equi,fraction}$ 1/h		c_{Air} Wh/(m³K)			
exterior $H_{V,e}$	390	*	0.004	*	0.33	=	0.5	W/K
without HR	390	*	0.021	*	0.33	=	2.7	W/K
ground $H_{V,g}$	390	*	0.050	*	0.33	=	6.5	W/K
without HR	390	*	0.279	*	0.33	=	35.9	W/K
Infiltration, window, extract air system	390	*	0.376	*	0.33	=	48.4	W/K

Additional night ventilation for cooling (summer)

Additional ventilation regulation

Minimum acceptable indoor temp. 22.0 °C

Type of additional ventilation

Window night ventilation, manual — Night ventilation rate 0.15 1/h

Mechanical, automatically controlled ventilation

Corresponding air change rate	0.30	1/h	Controlled by (please check)
Specific electric efficiency	x	Wh/m³	Temperature diff. x
released as heat into the building			Humidity diff.
Temperature increase	0.0	K	

Results passive cooling

Overheating limit ϑ_{max}:	25	°C
Frequency of overheating:		
Max. humidity:		g/kg
Frequency of excessively high humidity:		

Results active cooling

Useful cooling demand:	0.1	kWh/(m²a)
Dehumidification demand:	0.0	kWh/(m²a)
Frequency of excessively high humidity:	0.0%	

Secondary calculation: basic ventilation through windows

Estimation of the window air exchange to ensure adequate air quality in summer

Description								
Open duration [h/d]	3	12						
Climate boundary conditions								
Temperature diff interior - exterior	4	4					K	
Wind velocity	1	1					m/s	
Window group 1								
Quantity	4	6						
Clear width	0.84	0.84					m	
Clear height	1.92	1.92					m	
Tilting window (check if appropriate)	x	x						
Opening width (for tilting windows)	0.055	0.055					m	
Window group 2 (cross ventilation)								
Quantity								
Clear width							m	
Clear height							m	
Tilting window (check if appropriate)								
Opening width (for tilting windows)							m	
Difference in height to window 1							m	
							Total	
Result: Air change rate	**0.05**	**0.31**	**0.00**	**0.00**	**0.00**	**0.00**	**0.36**	**1/h**

Secondary calculation: Additional night ventilation through windows

Parameters for additional night ventilation through windows for cooling in summer

Description								
Reduction factor	100%							
Climate boundary conditions								
Temperature diff interior - exterior	1	1	1	1	1	1	K	
Wind velocity	0	0	0	0	0	0	m/s	
Window group 1								
Quantity	1							
Clear width	0.84						m	
Clear height	1.92						m	
Tilting window (check if appropriate)	x							
Opening width (for tilting windows)	0.055						m	
Window group 2 (cross ventilation)								
Quantity	2							
Clear width	0.84						m	
Clear height	1.92						m	
Tilting window (check if appropriate)	x							
Opening width (for tilting windows)	0.055						m	
Difference in height to window 1	0.00						m	
							Total	
Result: Night ventilation rates	**0.15**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.15**	**1/h**

Summer: Passive cooling

End-of-terrace Passive House / Climate: PHPP-Standard / TFA: 156 m² / Heating: 10.8 kWh/(m²a) / Cooling: 0.1 kWh/(m²a) / PER: 37.4 kWh/(m²a)

Building type:	4-Row house		Treated floor area A_{TFA}:	156.0	m²
Overheating limit:	25	°C	Building volume:	390	m³
Max. indoor absolute humidity:	12	g/kg	Internal humidity sources:	1.9	g/(m²h)
Spec. capacity:	204	Wh/(m²K)			

Transmittance

Building assembly	Temperature zone	Area m²		U-value W/(m²K)		Temperature reduction factor		H_{Summer} heat conductance
External wall - ambient	A	184.3	*	0.118	*	1.00	=	21.8
External wall ground/basement	B		*		*	1.00	=	
Roof / ceiling - ambient	A	83.4	*	0.108	*	1.00	=	9.0
Floor slab / basement ceiling	B	80.9	*	0.185	*	1.00	=	15.0
	A		*		*	1.00	=	
	A		*		*	1.00	=	
	A		*		*	1.00	=	
Windows	A	43.5	*	0.712	*	1.00	=	30.9
Exterior door	A		*		*	1.00	=	
Thermal bridges ambient (length/m)	A	122.9	*	-0.024	*	1.00	=	-2.9
Perimeter thermal bridges (length/m)	P		*		*	1.00	=	
Thermal bridges ground (length/m)	B	11.4	*	0.061	*	1.00	=	0.7

Exterior thermal transmittance $H_{T,e}$ = **58.8** W/K

Ground thermal transmittance, $H_{T,g}$ = **15.7** W/K

Summer ventilation

from 'SummVent' worksheet

Ventilation conductance, unit

exterior $H_{V,e}$	0.5	W/K
without HR	2.7	W/K
ground $H_{V,g}$	6.5	W/K
without HR	35.9	W/K

Ventilation conductance, others

exterior	48.4	W/K

Ventilation system

η_{HR}	82%
η_{ERV}	0%
η^*_{SHX}	93%

Ventilation parameters

Daily temperature fluctuation in summer	11.7	K
Minimum acceptable indoor temperature	22.0	°C
Heat capacity air	0.33	Wh/(m³K)
Supply air change rate	0.30	1/h
Outdoor air change rate	0.38	1/h
Window night ventilation air change rate, manual @ 1K	0.15	1/h
Air change rate due to mech. automatically controlled vent.	0.30	1/h
Specific electricity consumption for this	x	Wh/m³
Temperature increase	0.0	K

Summer ventilation control

	HRV/ERV
None	x
Temperature controlled	
Enthalpy controlled	
Always	
	Additional ventilation
Temperature controlled	x
Enthalpy controlled	

Solar aperture

Orientation of the area	Angle factor Summer		Shading factor Summer		Dirt		g-value (perp. radiation)		Area m²		Glazing fraction		Aperture m²
North	0.9	*	0.84	*	0.95	*	0.50	*	11.0	*	68%	=	2.7
East	0.9	*	1.00	*	0.95	*	0.00	*	0.0	*	0%	=	0.0
South	0.9	*	0.36	*	0.95	*	0.50	*	30.4	*	69%	=	3.2
West	0.9	*	0.30	*	0.95	*	0.50	*	2.0	*	58%	=	0.1
Horizontal	0.9	*	1.00	*	0.95	*	0.00	*	0.0	*	0%	=	0.0
Sum opaque areas													0.9

Solar aperture = **7.0**

Internal heat gains Q_I

Specif. power q_I W/m²		A_{TFA} m²		W
2.4	*	156	=	**378**

Frequency of overheating $h_{\vartheta \geq Jmax}$

0.0%

At the overheating limit ϑ_{max} = 25 °C

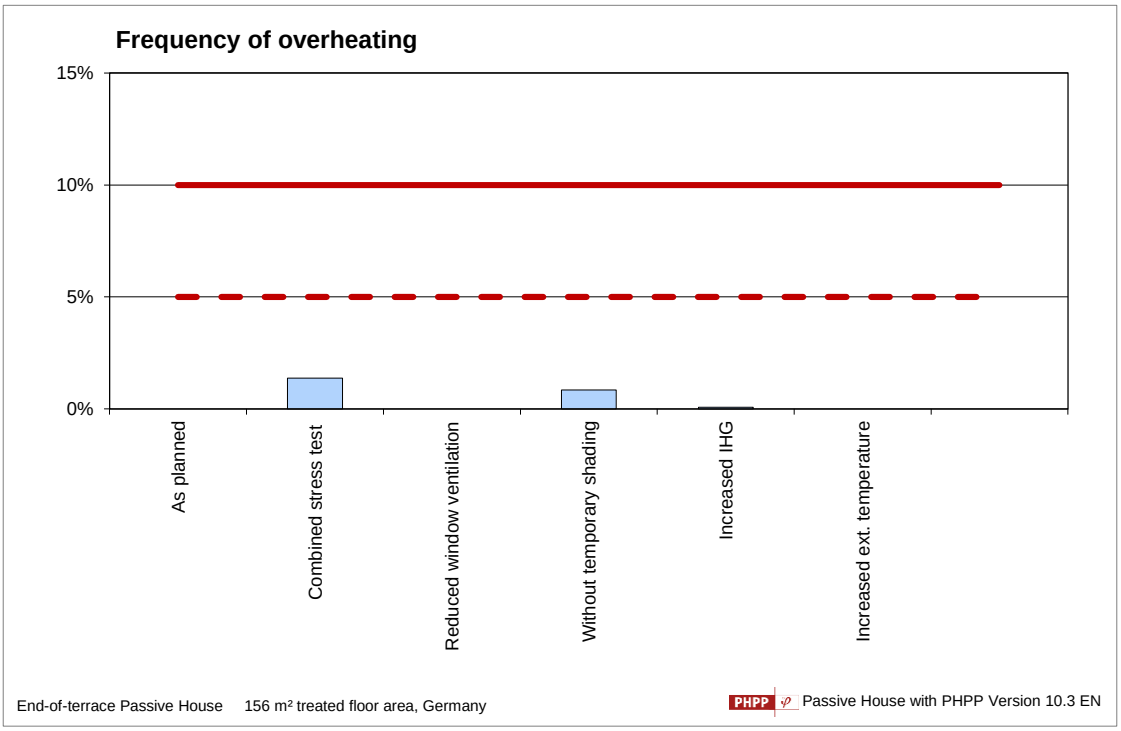
Recommendation: maximum 5%. If the frequency of overheating (25 ° C) exceeds 10%, additional measures to protect against summer heat are mandatory.

Overheating degree hours **0** Kh

Daily indoor temperature variation **0.6** K

Stress test for summer comfort

		As planned	Combined stress test	Reduced window ventilation	Without temporary shading	Increased IHG	Increased ext. temperature	Manual input
User influence								
Basic summer ventilation via windows	1/h	0.35	0.00	0.00	0.35	0.35	0.35	
Additional night ventilation via windows	1/h	0.15	0.10	0.00	0.15	0.15	0.15	
Use of temporary shading	-	90%	70%	90%	0%	90%	90%	
Internal heat gains	W/m²	2.4	3.0	2.4	2.4	4.8	2.4	
Summer climate								
Summer temperature increase	K	0.0	1.5	0.0	0.0	0.0	2.0	
Results								
Frequency of overheating		**0%**	**1%**	**0%**	**1%**	**0%**	**0%**	**-**
Overheating degree hours	Kh	**0**	**81**	**0**	**40**	**1**	**0**	**-**
Daily indoor temperature variation	K	**0.6**	**0.7**	**0.6**	**0.9**	**0.7**	**0.6**	**-**



Cooling: specific energy demand for useful cooling

End-of-terrace Passive House / Climate: PHPP-Standard / TFA: 156 m² / Heating: 10.8 kWh/(m²a) / Cooling: 0.1 kWh/(m²a) / PER: 37.4 kWh/(m²a)

The sum of the cooling periods calculated through the monthly method is presented on this worksheet.

Building type:	4-Row house		Treated floor area A_{TFA}:	156.0	m²
Interior temperature summer:	25	°C	Building volume:	390	m³
Max. indoor absolute humidity:	12	g/kg	Internal humidity sources:	1.9	g/(m²h)
Spec. capacity:	204	Wh/(m²K)			

Transmission losses Q_T (negative: heat loads)

Building assembly	Temperature zone	Area m²		U-value W/(m²K)		Temperature reduction factor		G_t kKh/a		kWh/a	Per m² of TFA
External wall - ambient	A	184.3	*	0.118	*	1.00	*	8	=	185	1.19
External wall ground/basement	B		*		*	1.00	*		=		
Roof / ceiling - ambient	A	83.4	*	0.108	*	1.00	*	8	=	76	0.49
Floor slab / basement ceiling	B	80.9	*	0.185	*	1.00	*	11	=	164	1.05
	A		*		*	1.00	*		=		
	A		*		*	1.00	*		=		
	A		*		*	1.00	*		=		
Windows	A	43.5	*	0.712	*	1.00	*	8	=	263	1.68
Exterior door	A		*		*	1.00	*		=		
Thermal bridges ambient (length/m)	A	122.9	*	-0.024	*	1.00	*	8	=	-25	-0.16
Perimeter thermal bridges (length/m)	P		*		*	1.00	*		=		0.00
Thermal bridges ground (length/m)	B	11.4	*	0.061	*	1.00	*	11	=	8	0.05
											kWh/(m²a)
Sum of all areas of the building envelope		392.1						**Total transmission heat losses Q_T**	=	**671**	**4.3**

Ventilation heat losses Q_V

Information from the 'SummVent' worksheet

Ventilation conductance, vent. unit

exterior $H_{V,e}$	0.5	W/K
without HR	2.7	W/K
ground $H_{V,g}$	6.5	W/K
without HR	35.9	W/K

Ventilation conductance, others

exterior	48.4	W/K

Ventilation system

η_{HR}	82%
η_{ERV}	0%
η^*_{SHX}	93%

Ventilation parameter s

Daily temperature fluctuation in summer	11.7	K
Minimum acceptable indoor temperature	22.0	°C
Heat capacity air	0.33	Wh/(m³K)
Supply air change rate	0.30	1/h
Outdoor air change rate	0.38	1/h
Window night vent. air change rate, manual @ 1K	0.15	1/h
Air change rate due to mech., autom. controlled vent.	0.30	1/h
Specific electricity consumption for this	x	Wh/m³
Temperature increase	0.0	K

Summer ventilation control

	HRV/ERV in summer
None	x
Temperature controlled	
Enthalpy controlled	
Always	
	Additional ventilation
Temperature controlled	x
Humidity controlled	

	$n_{V,system}$ 1/h		η^*_{SHX}		η_{HR} (considers bypass)		$n_{V,Rest}$ 1/h	=	$n_{V,equi,fraction}$ 1/h
Hygienic change rate:									
Effective air change rate ambient $n_{V,e}$	0.300	*(1-	93%	)*(1-	0.00	)+	0.376	=	0.397
Effective air change rate ground $n_{V,g}$	0.300	*	93%	*(1-	0.00	)		=	0.279

	V_V m³		$n_{V,equi,fraction}$ 1/h		c_{Air} Wh/(m³K)		G_t kKh/a	=	kWh/a	kWh/(m²a)
Ventilation losses ambient Q_V	390	*	0.397	*	0.33	*	8	=	411	2.6
Ventilation losses ground $Q_{V,e}$	390	*	0.279	*	0.33	*	17	=	621	4.0
Heat losses summer ventilation	390	*	0.509	*	0.33	*	10	=	673	4.3
							Total ventilation heat losses Q_V	=	**1705**	**10.9**

Total heat losses Q_L

Q_T kWh/a	+	Q_V kWh/a	=	kWh/a	kWh/(m²a)
671	+	1705	=	**2376**	**15.2**

Available solar heat gains Q_S

Orientation of the area	Reduction factor		g-value (perp. radiation)		Area m²		Global radiation kWh/(m²a)		kWh/a	kWh/(m²a)
North	0.49	*	0.50	*	11.0	*	78	=	210	1.3
East	0.40	*	0.00	*	0.0	*	130	=	0	0.0
South	0.27	*	0.50	*	30.4	*	143	=	595	3.8
West	0.19	*	0.50	*	2.0	*	128	=	25	0.2
Horizontal	0.40	*	0.00	*	0.0	*	225	=	0	0.0
Sum opaque areas									121	0.8
										kWh/(m²a)
								Total	**951**	**6.1**

Internal heat gains Q_I

	kh/d		Length cooling period d/a		Spec. power q_I W/m²		A_{TFA} m²		kWh/a	kWh/(m²a)
	0.024	*	48	*	2.4	*	156.0	=	**435**	**2.8**

Sum heat loads Q_F

$Q_S + Q_I$ = **1386** kWh/a | **8.9** kWh/(m²a)

Utilisation factor heat losses η_L

Ratio of losses to free heat gains Q_L / Q_F = 1.71

Utilisation factor heat losses η_V = 57%

		kWh/a	kWh/(m²a)
Useful heat losses $Q_{V,n}$	$\eta_L * Q_L$ =	**1365**	**8.8**
Useful cooling demand Q_K	$Q_F - Q_{V,n}$ =	**21**	**0.1**

	kWh/(m²*a)		
Recommendation	15	**Target value reached?**	**Yes**

Dehumidification demand Q_{Dr}

Q_{Tr} = **0** | **0.0**

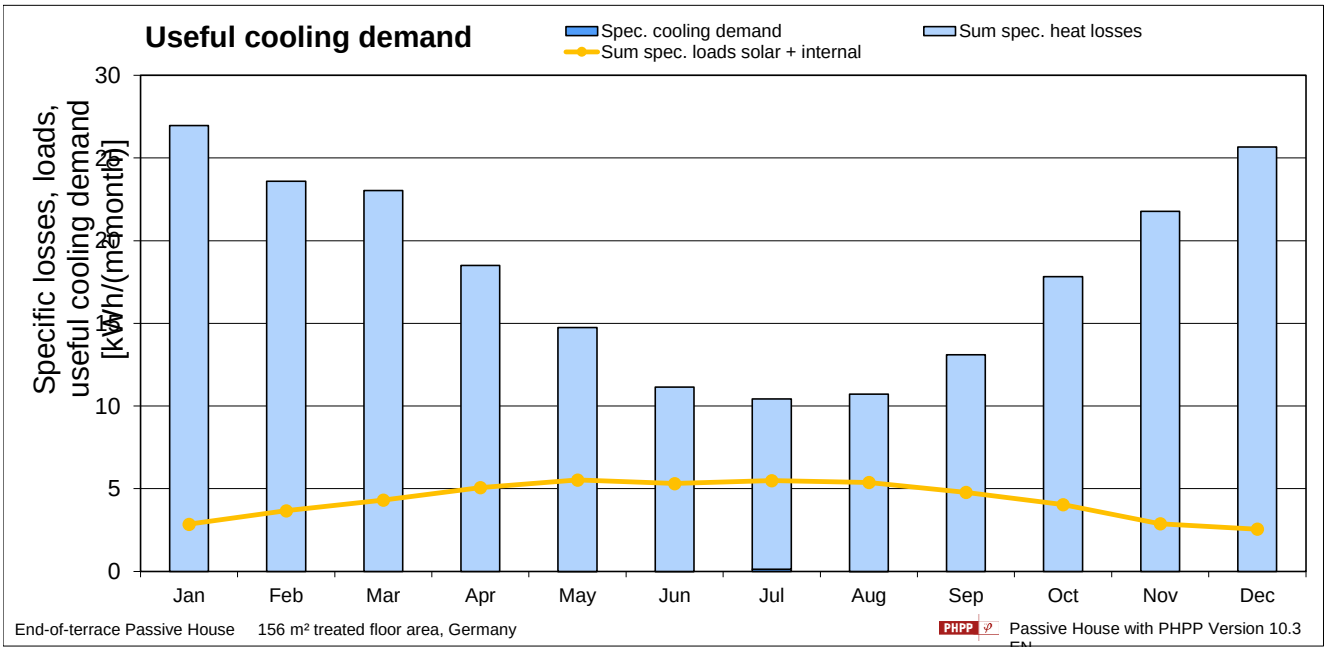
	kWh/(m²*a)		
Recommendation	0	**Target value reached?**	**Yes**

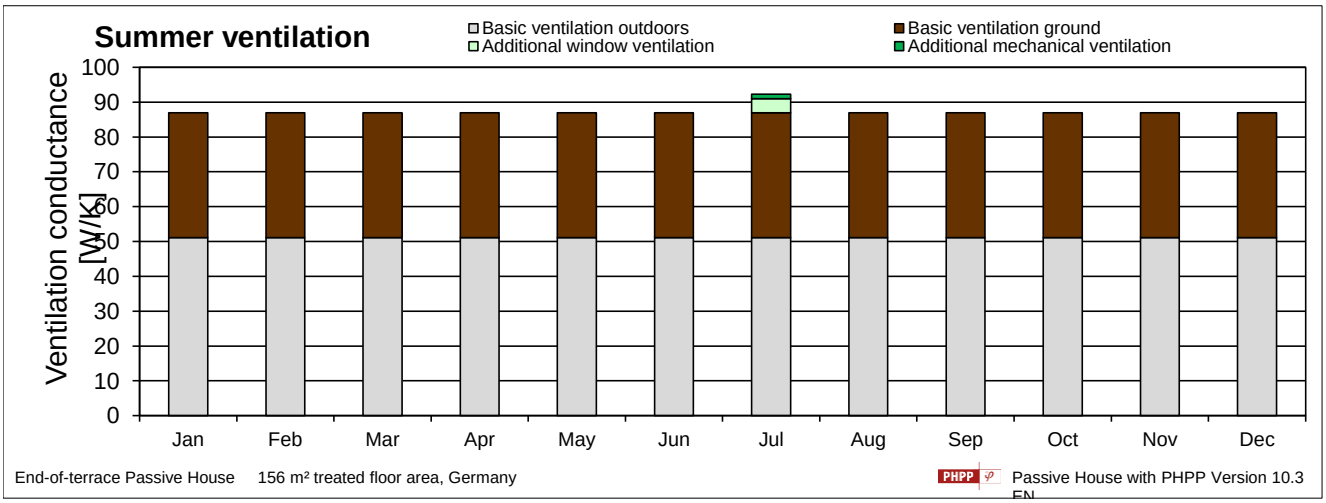
Cooling: specific energy demand for useful cooling

End-of-terrace Passive House / Climate: PHPP-Standard / TFA: 156 m² / Heating: 10.8 kWh/(m²a) / Cooling: 0.1 kWh/(m²a) / PER: 37.4 kWh/(m²a)

Building type:	4-Row house	
Interior Temperature:	25	°C
Treated floor area A_{TFA}:	156	m²

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	
Heating degree hours - Exterior	18.8	16.4	15.8	12.4	9.4	6.6	5.8	6.2	8.3	11.9	15.0	17.8	145	kKh
Heating degree hours - Ground	6.2	6.2	7.6	7.8	8.2	7.8	7.5	6.8	6.0	5.7	5.3	5.7	81	kKh
Losses - Exterior	2039	1777	1711	1342	1013	709	623	670	895	1295	1629	1938	15642	kWh
Losses - Ground	499	460	520	511	530	510	519	508	482	490	472	491	5990	kWh
Losses summer ventilation	1668	1443	1361	1033	757	519	463	493	668	997	1295	1574	12272	kWh
Sum spec. heat losses	27.0	23.6	23.0	18.5	14.7	11.1	10.3	10.7	13.1	17.8	21.8	25.7	217.3	kWh/m²
Solar load North	27	40	70	100	135	148	148	119	81	49	27	19	963	kWh
Solar load East	0	0	0	0	0	0	0	0	0	0	0	0	0	kWh
Solar load South	121	245	274	345	353	316	333	357	333	262	133	87	3159	kWh
Solar load West	3	5	9	13	16	15	16	14	11	7	3	2	113	kWh
Solar load Horiz.	0	0	0	0	0	0	0	0	0	0	0	0	0	kWh
Solar load Opaque	14	26	39	60	77	77	78	69	50	31	15	10	547	kWh
Internal heat gains	281	254	281	272	281	272	281	281	272	281	272	281	3308	kWh
Sum spec. loads solar + internal	2.9	3.7	4.3	5.1	5.5	5.3	5.5	5.4	4.8	4.0	2.9	2.6	51.9	kWh/m²
Utilisation factor losses	11%	16%	19%	27%	37%	48%	52%	50%	36%	23%	13%	10%	24%	
Useful cooling energy demand	0	0	0	0	0	0	21	0	0	0	0	0	21	kWh
Spec. cooling demand	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.1**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.1**	kWh/m²
Specif. dehumidification demand	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	kWh/m²
Sensible fraction	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	





Cooling units

Passive House with PHPP Version 10.3 EN

End-of-terrace Passive House / Climate: PHPP-Standard / TFA: 156 m² / Heating: 10.8 kWh/(m²a) / Cooling: 0.1 kWh/(m²a) / PER: 37.4 kWh/(m²a)

Building type:	4-Row house		Treated floor area A_{TFA}:	156.0	m²
Interior temperature summer:	25.0	°C	Mechanical cooling:	x	
Max. indoor absolute humidity:	12.0	g/kg	Air change rate via ventilation system with supply air:	0.3	1/h
Internal humidity sources:	1.9	g/(m²h)	Building volume:	390	m³

Operation time: 12.0 hours per day; 7.0 days a week

x Supply air cooling (w/ recirculating air if necessary)

Number of units: 1.0

Selection list of units: 1-Combined ventilation/split units

Selection unit: 1441ch03-Aernova, ETHOS 007 RS

Go to list of combined ventilation/split units

2-Sort by ID

Go to list of HPs according to EN 14825 / EN 14511

	Normal operation		Dehumidification mode	
Recirculation airflow	500 m³/h		0 m³/h	
Variable?	x			
Total cooling coil	734 m³/h		234 m³/h	
Internal heat recovery	0%		0%	

T_e-T_i	Cooling capacity kW		EER		Cooling capacity kW		EER	
K	maximum	on-off limit	maximum	on-off limit	maximum	on-off limit	maximum	on-off limit
10	5.50	1.40	2.20	1.60	4.00	1.50	2.80	2.40
5	5.60	1.40	2.70	1.90	3.80	1.60	3.40	3.20
0	5.60	1.50	3.10	2.30	3.60	1.60	3.70	3.50
Dry temperature diff.	23.1	K			51.8	K		

Reduction coefficient Cc: 0.92

Reheating capacity: kW

Performance ratio of reheating:

Seasonal energy efficiency ratio: 1.5

Recirculation cooling

Number of units:

Selection list of units:

Selection unit:

Go to list of combined ventilation/split units

1-Sorting: AS LIST

Go to list of HPs according to EN 14825 / EN 14511

	Normal operation		Dehumidification mode	
Nominal airflow rate	m³/h		m³/h	
Variable?				

T_a-T_i	Cooling capacity kW		EER		Cooling capacity kW		EER	
K	maximum	on-off limit	maximum	on-off limit	maximum	on-off limit	maximum	on-off limit
Dry temperature diff.		K				K		

Silent mode:

Noise level: 0 dB(A)

Reduction coefficient Cc:

Reheating capacity: kW

Performance ratio of reheating:

Seasonal energy efficiency ratio:

Additional dehumidification

Waste heat to room (check if appropriate):

Seasonal energy efficiency ratio:

Panel cooling

Selection unit:

Go to list of HPs according to EN 14825 / EN 14511

1-Sorting: AS LIST

	Normal operation				No dehumidification
T_a-T_i	Cooling capacity kW		EER		
K	maximum	on-off limit	maximum	on-off limit	

Reduction coefficient Cc:

Seasonal energy efficiency ratio:

Results

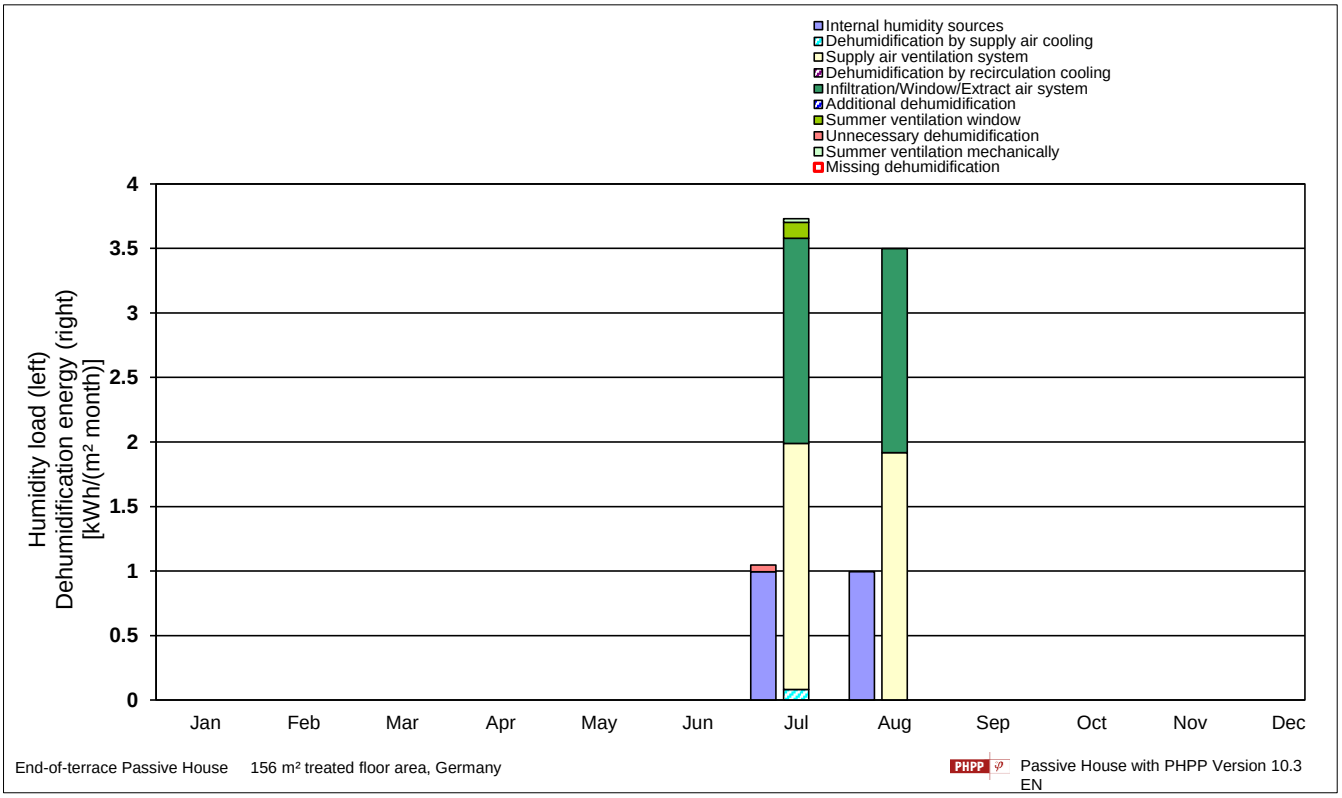
		Sensible kWh/(m²a)		Latent kWh/(m²a)		SEER		Electricity demand kWh/(m²a)	Sensible fraction
Cooling contribution by:	Supply air cooling	(0.1	+	0.1	) /	1.5	=	0.1	62%
	Recirculation cooling	(	+		) /		=		
	Dehumidification				/		=		0%
	Panel cooling				/		=		100%
	Post heating	0.0			/	-	=	0.0	100%
	Cooling distribution				/	1.5	=		100%
Total cooling contribution		(0.1	+	0.1	) /	1.5	=	0.1	62%
Useful cooling demand		0.1		0.0					100%
Unsatisfied demand		0.0		0.0				**Cooling demand covered?**	**Yes**

Cooling units

End-of-terrace Passive House / Climate: PHPP-Standard / TFA: 156 m² / Heating: 10.8 kWh/(m²a) / Cooling: 0.1 kWh/(m²a) / PER: 37.4 kWh/(m²a)

Humidity loads and humidity removal

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	
Internal humidity sources	1.0	0.9	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	12	kWh/m²
Infiltration/Window/Extract air system	-5.1	-4.6	-4.7	-4.1	-3.2	-2.2	-1.6	-1.6	-2.4	-3.6	-4.3	-4.9	-42	kWh/m²
Supply air ventilation system	-4.1	-3.7	-3.7	-3.3	-2.6	-1.9	-1.9	-1.9	-1.9	-2.8	-3.5	-3.9	-35	kWh/m²
Summer ventilation window	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	0.0	0.0	0.0	0	kWh/m²
Summer ventilation mechanically	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	kWh/m²
Total humidity load	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	kWh/m²
Dehumidification by supply air cooling	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0	kWh/m²
Dehumidification by recirculation cooling	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	kWh/m²
Additional dehumidification	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	kWh/m²
Total dehumidification	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0	
Unnecessary dehumidification	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0	kWh/m²
Missing dehumidification	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	kWh/m²



Cooling load

End-of-terrace Passive House / Climate: PHPP-Standard / TFA: 156 m² / Heating: 10.8 kWh/(m²a) / Cooling: 0.1 kWh/(m²a) / PER: 37.4 kWh/(m²a)

Building type:	4-Row house	
Treated floor area A_{TFA}:	156.0	m²
Building volume:	390	m³
Spec. capacity:	204	Wh/(m²K)
Max. indoor absolute humidity:	12.0	g/kg
Internal humidity sources:	1.9	g/(m²h)
Interior temperature summer:	25	°C
SHX	10.0	°C

From 'Climate' worksheet:

Temperature:	Weather 1 °C	Weather 2 °C
Outdoor air	24.0	24.0
Dew point	15.9	15.9
Sky	13.1	13.1
Ground design temp.		14.9 °C
Daily temperature swing		11.7 K

Radiation:	Weather 1 W/m²	Weather 2 W/m²
North	100	100
East	180	180
South	200	200
West	180	180
Horizontal	330	330

Transmission heat load P_T

Building assembly	Temperature zone	Area m²		U-value W/(m²K)		Temperature reduction factor		Temp Diff 1 K		Temp Diff 2 K		P_T 1 W		P_T 2 W
External wall - ambient	A	184.3	*	0.118	*	1.00	*	-1.0	or	-1.0	=	-22	or	-22
External wall ground/basement	B		*		*	1.00	*	-10.1	or	-10.1	=		or	
Roof / ceiling - ambient	A	83.4	*	0.108	*	1.00	*	-1.0	or	-1.0	=	-9	or	-9
Floor slab / basement ceiling	B	80.9	*	0.185	*	1.00	*	-10.1	or	-10.1	=	-152	or	-152
	A		*		*	1.00	*	-1.0	or	-1.0	=		or	
	A		*		*	1.00	*	-1.0	or	-1.0	=		or	
	A		*		*	1.00	*	-1.0	or	-1.0	=		or	
Windows	A	43.5	*	0.712	*	1.00	*	-1.0	or	-1.0	=	-31	or	-31
Exterior door	A		*		*	1.00	*	-1.0	or	-1.0	=		or	
Thermal bridges ambient (length/m)	A	122.9	*	-0.024	*	1.00	*	-1.0	or	-1.0	=	3	or	3
Perimeter thermal bridges (length/m)	P		*		*	1.00	*	-10.1	or	-10.1	=		or	
Thermal bridges ground (length/m)	B	11.4	*	0.061	*	1.00	*	-10.1	or	-10.1	=	-7	or	-7
Building element towards neighbour	I	100.9	*	0.375	*	1.00	*	3.0	or	3.0	=	114	or	114
Radiation correction outdoor air				$L_{ambient}$ W/K		-3.8	*	-1.0	or	-1.0	=	4	or	4
Radiation correction sky				L_{Sky} W/K		3.8	*	-11.9	or	-11.9	=	-45	or	-45
										Total transmission heat load P_T	=	**-145**	or	**-145**

Ventilation heat load P_V

	V_V m³		$n_{V,equi,fraction}$ 1/h		$n_{V,equi,fraction}$ 1/h		c_{Air} Wh/(m³K)		TempDiff 1 K		TempDiff 2 K		P_V 1 W		P_V 2 W
Ventilation load ambient $P_{V,a}$	390	*	0.397	or	0.397	*	0.33	*	-1.0	or	-1.0	=	-51	or	-51
Ventilation load ground $P_{V,g}$	390	*	0.279	or	0.279	*	0.33	*	-15.0	or	-15.0	=	-539	or	-539
Ventilation load summer ventilation	390	*	0.317	or	0.317	*	0.33	*	-4.5	or	-4.5	=	-184	or	-184
										Total ventilation heat load P_L	=	**-774**	or	**-774**

Solar load P_S

Orientation of the area	Area m²		g-value (perp. radiation)		Reduction factor (see 'Windows' worksheet)		Radiation 1 W/m²		Radiation 2 W/m²		P_T 1 W		P_T 2 W
North	11.0	*	0.5	*	0.49	*	100	or	100	=	270	or	270
East	0.0	*	0.0	*	0.40	*	180	or	180	=	0	or	0
South	30.4	*	0.5	*	0.21	*	200	or	200	=	644	or	644
West	2.0	*	0.5	*	0.15	*	180	or	180	=	27	or	27
Horizontal	0.0	*	0.0	*	0.40	*	330	or	330	=	0	or	0
Sum opaque areas											173	or	173
									Total solar load P_S	=	**1113**	or	**1113**

Internal heating load P_I

Spec. power W/m²		A_{TFA} m²	=	P_I 1 W		P_I 2 W
2.4	*	156	=	**378**	or	**378**

Cooling load P_C

$P_T + P_V + P_S + P_I$ = **571** or **571**

Cooling load P_C = **571** W

Area specific cooling load P_C / A_{TFA} = **3.7** W/m²

For comparison: cooling capacity that can be transported by the supply air

Please enter the minimum supply air temperature: 3 °C

Supply air temperature without cooling $\vartheta_{Supply,Min}$ = 11.0 °C 11.0

Cooling capacity that can be transported by the supply air $P_{Supply\ air;max}$ = **308** W **308**

$P_{Supply\ air;\ max}/A_{TFA}$ = 2.0 W/m² 2.0

Air conditioning over the supply air possible? **No**

Conductance values			**Performance**		
Transmittance	58.8	W/K	Transmission + Ventilation	321	W
Ventilation conductance	51.1	W/K	Solar load	2227	W
Conductance summer ventilati	40.8	W/K	Internal load	755	W
Heat capacity	31824	Wh/K	Night ventilation	119	W

Part of the day	P [W]	ΔT [K]
13	-441	-0.4
6 h - 12 h	2601	-0.1
12 h - 18 h	3303	0.2
18 h - 24 h	262	0.0
Average value	1431	

Cross check: daily indoor temperature fluctuation

Daily indoor temperature fluctuation = **0.6** K

Dehumidification load P_T

from 'Cooling' worksheet

Humidity ambient air	11.3	or	11.3	g/kg	Humidity supply air	8.1	or	8.1	g/kg
Outdoor air mass flow	173	or	173	kg/h	Supply air mass flow	138	or	138	kg/h
Summer vent. air mass flow	152	or	152	kg/h	**Hum. load, supply air**	-532	or	-532	g/h
Humidity load, outdoor air	-221	or	-221	g/h	**Hum. load, internal**	295	or	295	g/h

Enthalpy of vaporisation Wh/kg		g/kg		Humidity load g/h		Humidity load g/h		P_D 1 W		P_D 2 W
708	/	1000	*	-458	or	-458	=	**0**	or	**0**

Dehumidification load P_T = **0** W

Area specific dehumidification load P_T / A_{TFA} = **0.0** W/m²

Monthly average values	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Specific cooling demand	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	kWh/m²
Specific dehumidification demand	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	kWh/m²
Sensible fraction	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	

Minimum sensible share of the cooling load = **100%**

Heat distribution and domestic hot water (DHW) system

End-of-terrace Passive House / Climate: PHPP-Standard / TFA: 156 m² / Heating: 10.8 kWh/(m²a) / Cooling: 0.1 kWh/(m²a) / PER: 37.4 kWh/(m²a)

Interior temperature:	20	°C	Interior temperature summer:	25	°C
Building type:	4-Row house				
Treated floor area A_{TFA}:	156	m²			
Number or occupants per day:	2.9	Pers			
Number of dwelling units:	1				
Annual heating demand $q_{Heating}$:	1687	kWh/a	Annual useful cooling dem. q_{Cool}:	21	kWh/a
Length of heating period:	151	d/a	Length cooling period:	48	d/a
Average heating load $P_{Average}$:	0.3	kW	Average cooling load $P_{Average}$:	0.0	kW
Marginal usability of additional heat gains:	79%		Marginal usability of additional heat losses:	7%	

Heat transfer:	
	Supply air
x	Radiators
	Underfloor heating or other panel heating
	Concrete core activation
	Split unit or similar
	Wood stove with direct heat emission
	Other

Space heat distribution

			Inside thermal envelope					Outside thermal envelope					Total values	
			1	2	3	4	5	1	2	3	4	5	Absolute	Specific
Length of distribution pipes (flow + return)	L_H	m	18.5											
Nominal width of pipe		mm	20											
Insulation thickness		mm												
Insulation alu-laminated?		-												
Thermal conductivity of insulation		W/(mK)	0.035											
Heat loss coefficient		W/(mK)	0.655											
Insulation quality of mountings, pipe suspensions, etc.		-												
Pipe mount thermal bridging supplement		W/K	4.775											
Total heat loss coefficient	Ψ	W/(mK)	**0.913**											
Room temperature	θ_X	°C	20	20	20	20	20	11.0	11.0	11.0	11.0	11.0		
Flow temperature	θ_V	°C	55	55	55	55	55	55	55	55	55	55		
System heating load	$P_{heating}$	kW	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4		
Flow temperature control?			x											
Common pipe Heating + DHW?														
Return temperature	ϑ_R	°C	45											
Heat emission pipe	q^*_{HL}	kWh/(m·a)	48											
Utilisation factor of released heat	η_G	-	79%											
													kWh/a	kWh/(m²a)
Heat losses of heating distribution	Q_{HL}	kWh/a	**184**										**184**	**1.2**
Heat losses of heating storage		kWh/a											**0**	**0.0**
Total heat losses of heating		kWh/a											**184**	**1.2**
Performance ratio of space heating distribution	$ea_{,HL}$	-											**111%**	

DHW useful heat

DHW demand for showers, per person and day (with 60 °C)		litre/person/d	16.0
DHW demand others, per person and day (with 60 °C)		litre/person/d	9.0
Performance of drain water heat recovery (shower)		-	0%
Effective DHW demand	V_{DHW}	litre/person/d	25
Average cold water temperature of the supply	θ_{TW}	°C	10.0
DHW demand for washing machines & dishwashers		kWh/a	188

		kWh/a	kWh/(m²a)
Useful heat of DHW	Q_{DHW}	**1750**	**11.2**

Secondary calculation for determining the DHW requirements

Secondary calculation: drain water heat recovery (shower)

DHW distribution

			Inside thermal envelope					Outside thermal envelope					Total values	
			1	2	3	4	5	1	2	3	4	5	Absolute	Specific
Room temperature	θ_X	°C						11.0	11.0	11.0	11.0	11.0		
DHW circulation pipes or, for heat interface units, flow and return														
Common pipe heating + DHW?														
Length of pipes (flow + return)	L_{HS}	m	13.5					2.00						
Nominal width of pipe		mm	20					20						
Insulation thickness		mm	40					40						
Insulation alu-laminated?		-												
Thermal conductivity of insulation		W/(mK)	0.035					0.035						
Heat loss coefficient		W/(mK)	0.135					0.135						
Insulation quality of mountings, pipe suspensions, etc.		-	3 - Good					3 - Good						
Thermal bridge surcharge mountings		W/K	0.208					0.150						
Total heat loss coefficient	Ψ	W/(mK)	**0.150**					**0.210**						
Daily operating time of circulation	td_{Circ}	h/d	18	18	18	18	18	18	18	18	18	18		
Flow temperature	θ_V	°C	60	60	60	60	60	60	60	60	60	60		
Pipes to heat interface unit?														
Return temperature	θ_R	°C	55					55						
Operating time of the circulation in winter	t_{Circ}	h/a	3940					6570						
Operating time of the circulation in summer	t_{Circ}	h/a	2630											
Heat loss circulation pipes in winter	QZ	kWh/a	**299**					**128**					kWh/a	kWh/(m²a)
Heat loss circulation pipes in summer	QZ	kWh/a	**173**										**600**	**3.8**
DHW stub pipes / individual pipes														
DHW temperature	θ_V	°C	60	60	60	60	60	60	60	60	60	60		
Exterior pipe diameter	d_{U_Pipe}	mm	12											
Total length of individual pipes	L_U	m	12.00											
Number of tapping points in building	$n_{tapping\ poin}$	-	3	3	3	3	3	3	3	3	3	3		
Average pipe length per tapping point	$L_{U,\ average}$	m	4.0											
Tap openings per person per day		-	6	6	6	6	6	6	6	6	6	6		
Utilisation days per year		d	365	365	365	365	365	365	365	365	365	365		
Number of tap openings per year and person	n_{Tap}	Openings/a	2190											
Heat emission per tap opening in winter	$q_{Individual}$	kWh/Opening	0.0143											
Heat emission per tap opening in summer	$q_{Individual}$	kWh/Opening	0.0125											
Heat emission from single pipes in winter	Q_U	kWh/a	**55**										kWh/a	kWh/(m²a)
Heat emission from single pipes in summer	Q_U	kWh/a	**32**										**88**	**0.6**

		kWh/a	kWh/(m²a)
Total heat losses of DHW distribution	Q_{WL}	**688**	**4.4**
Performance ratio of DHW distribution pipes	$ea_{,HL}$ -	**139%**	

Storage heat losses

		Storage type 1	Storage type 2	Buffer storage tank (only heating)	Compact unit		
Selection of storage tank		1-DHW and heating	0-No storage tank	0-No storage tank	0-No		
Storage necessary for HP		x	---------	(x)	---------		
Solar DHW connection		x		---------			
Heat loss rate	W/K	3.0					
Storage volume	litre	700			---------		
Standby fraction	-	30%		---------	---------		
Location of storage tank, inside or outside of thermal envelope		2-Outside	1-Inside	1-Inside			
Temperature of mechanical room	°C	11.0					
Typical storage tank temperature	°C	60.0					
Manual entry of storage temperature	°C				---------		
Average standby heat losses storage tank	W	44					
Additional heat loss storage, solar system operation	W	103		---------	---------		
Possible utilisation factor of heat losses		---------	---------		---------		
						kWh/a	kWh/(m²a)
Annual heat losses DHW storage tank	kWh/a	386			---------	**386**	**2.5**
Annual heat losses buffer storage tank	kWh/a						

Auxiliary calculation - heat losses through storage tank according to EU efficiency classes

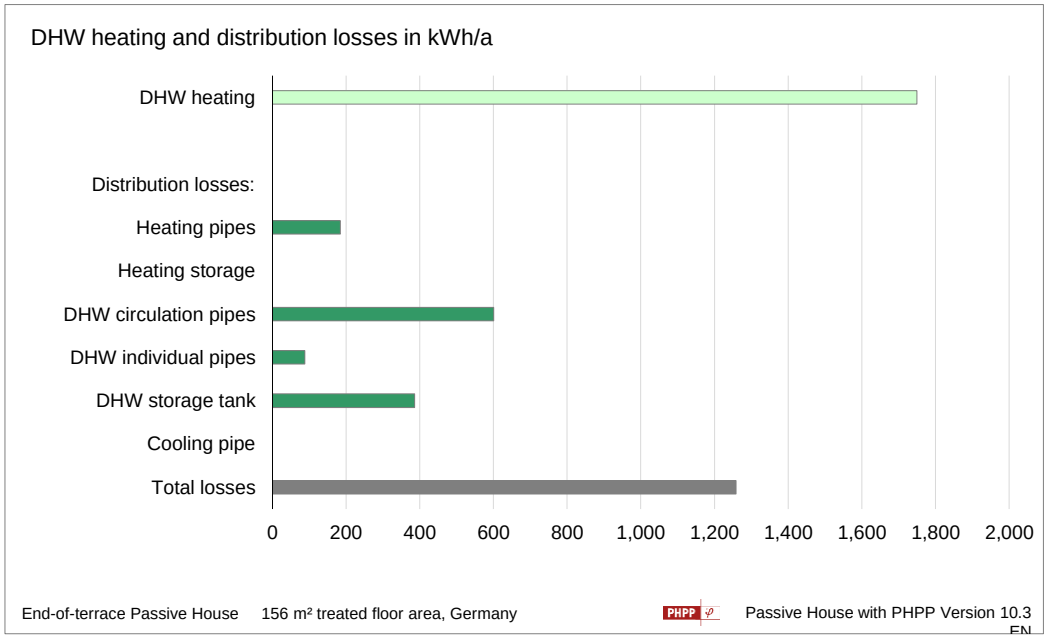
Storage tank volume	Litre			
ErP classification	-	C	C	C
Maximum permissible standby heat loss	W			
Heat loss ratio for PHPP calculation	W/K			

Total energy demand of DHW

		kWh/a	kWh/(m²a)
Heat losses of DHW distribution and storage	Q_{WL}	**1075**	**6.9**
Performance ratio DHW distribution + storage	$e_{a,WL}$	**161%**	
Total heat demand of DHW system including storage tank	Q_{gDHW}	**2824**	**18.1**

Cooling distribution

			Inside thermal envelope					Outside thermal envelope					Total values	
			1	2	3	4	5	1	2	3	4	5	Absolute	Specific
Length of distribution pipes	L_H	m												
Nominal width of pipe		mm												
Insulation thickness		mm												
Insulation alu-laminated?		-												
Thermal conductivity of insulation		W/(mK)												
Heat loss coefficient per m pipe	Ψ	W/(mK)												
Temp. of room through which the pipes pass	θ_X	°C	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0		
Design flow temperature	θ_V	°C	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0		
System cooling load	P_{Cool}	kW												
Flow temperature control ('x' if appropriate)														
Design return temperature	θ_R	°C												
Annual heat absorption per m of pipe	q^*_{HL}	kWh/(m·a)												
Possible utilisation factor of this heat absorption	η_G	-												
Annual losses of cooling distribution	Q_{HL}	kWh/a											kWh/a	kWh/(m²a)
													0	**0.0**
Performance ratio cold water distribution pipes	$ea_{,HL}$	-											**100%**	



End-of-terrace Passive House 156 m² treated floor area, Germany Passive House with PHPP Version 10.3 EN

Solar thermal system

End-of-terrace Passive House / Climate: PHPP-Standard / TFA: 156 m² / Heating: 10.8 kWh/(m²a) / Cooling: 0.1 kWh/(m²a) / PER: 37.4 kWh/(m²a)

Building type:	4-Row house	
Treated floor area A_{TFA}:	156.0	m²
Projected building footprint $A_{Projected}$:	80.9	m²
Latitude *('Climate' worksheet)*	51.3	°
DHW heat demand (sheet DHW + distribution)	2824	kWh/a
Heating demand ('Heating' and 'DHW+Distribution' worksheets)	1871	kWh/a
No. of occupants	2.9	Persons

Location: Selection in 'Areas' worksheet	4-Roof	
Size of selected area	83	m²
Free area (less solar thermal and electrical systems)	22.9	m²
Deviation from North	0	°
Angle of inclination from the horizontal	0	°
Alternative input: deviation from North		°
Alternative input: angle of inclination from the horizontal	0	°

Collector	7-Improved flat plate collector	
Supplementary heating (check if appropriate)	x	
DHW priority (check if appropriate)	0.0	

Solar collector area		5.40	m²
Specific collector area		1.8	m²/Pers
Height of the collector field		1.00	m
Height of horizon	h_{Hori}	0.00	m
Distance of horizon	a_{Hori}	1000.00	m
Additional reduction factor shading	r_{other}	100%	

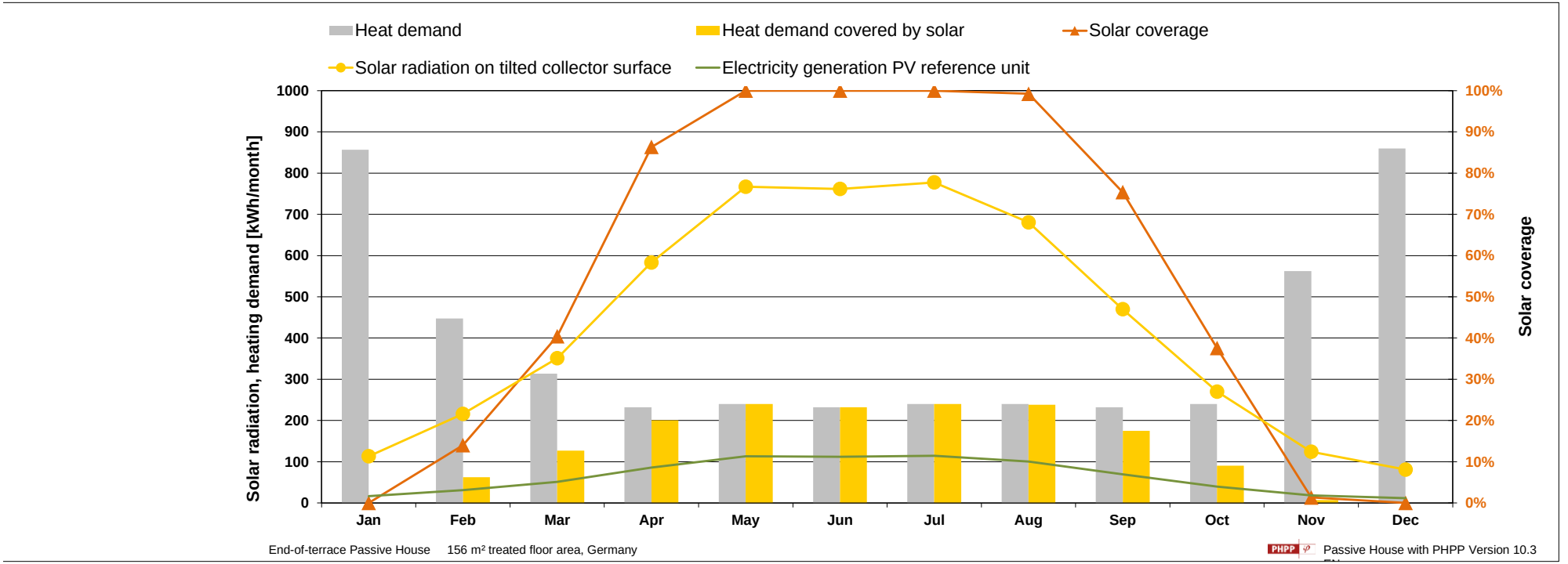
Results

		Projected building footprint area	Absolute
		kWh/($m^2_{Projected}$*a)	kWh/a
Solar contribution total	**34%**	**19.9**	**1612**
Solar contribution to DHW	**52%**	**18.3**	**1480**
Solar contribution to space heating	**7%**	**1.6**	**133**

Determination of PER factors

Yield reference PV syst.	PER_{el}	$PER_{Sol.therm}$
kWh_{el}/a	$kWh_{prim-el}/kWh_{el}$	$\frac{kWh_{el}}{kWh_{th}} * kWh_{prim-el}/kWh_{el}$
763	1.34	0.35
700.7	1.30	**0.36**
62.8	1.80	**0.26**

			$kgCO_2eq/a$	$kgCO_2eq/a$
1-CO2 factors GEMIS (Germany)	kgCO2eq/ kWhFinal	0.045	**0.9**	**73**



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	
Heat demand DHW generation	240	217	240	232	240	232	240	240	232	240	232	240	2824	kWh/month
Heat demand space heating	617	231	74	0	0	0	0	0	0	0	330	620	1871	kWh/month
Heat demand	857	447	313	232	240	232	240	240	232	240	562	860	4696	kWh/month
Solar radiation on tilted collector surface	113	216	351	583	767	761	778	680	470	270	124	81	5195	kWh/month
Input: Solar yield DHW													0	kWh/month
Input: Solar yield heating													0	kWh/month
Heat demand covered by solar, DHW	0	4	61	200	240	232	240	238	175	90	0	0	1480	kWh/month
Heat demand covered by solar, space heating	0	59	66	0	0	0	0	0	0	0	7	0	133	kWh/month
Heat demand covered by solar	0	63	127	200	240	232	240	238	175	90	7	0	1612	kWh/month
Solar coverage	0%	14%	40%	86%	100%	100%	100%	99%	75%	38%	1%	0%	34%	-
Electricity generation PV reference unit	16	31	51	86	113	112	115	100	69	40	18	12	763	kWh/month

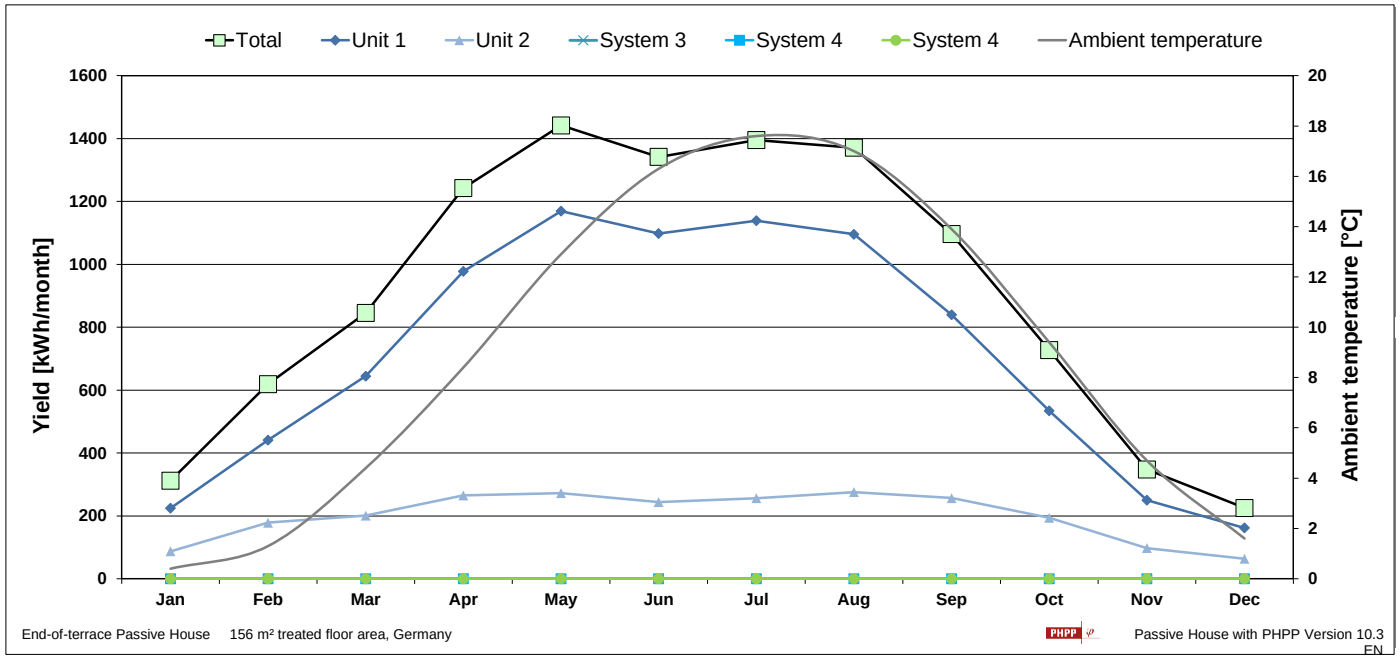
Photovoltaic systems

End-of-terrace Passive House / Climate: PHPP-Standard / TFA: 156 m² / Heating: 10.8 kWh/(m²a) / Cooling: 0.1 kWh/(m²a) / PER: 37.4 kWh/(m²a)

Climate data set:	DE-9999-PHPP-Standard	
Building type:	4-Row house	
Projected building footprint:	80.9	m²

Name of system		Unit 1	Unit 2	System 3	System 4	System 4	Reference PV syst.	
Location: Selection in 'Areas' worksheet		4-Roof	1-External wall south				4-Roof	
Size of selected area		83.4	43.1				83.4	m²
Deviation from North		180	180				0	°
Angle of inclination from horizontal		30	90				0	°
Alternative input: deviation from north		180						°
Alternative input: angle of inclination from horizontal		30						°
Information from the PV module data sheet for standard test conditions (STC)								
Technology		4-Mono-Si	5-Poly-Si				4-Mono-Si	
Nominal current	I_{MPP0}	10.00	9.30				10.00	A
Nominal voltage	U_{MPP0}	34.00	33.00				34.00	V
Nominal power	P_n	340	307	0	0	0	340	Wp
Temperature coefficient short-circuit current	α	0.050	0.050				0.050	%/K
Temperature coefficient open-circuit voltage	β	-0.270	-0.280				-0.270	%/K
PV module dimensions: height		1.750	1.700				1.750	m
PV module dimensions: width		1.050	1.000				1.050	m
							1.8	PV module area [m²]
Further specifications								
Number of PV modules	n_M	30	16				2.9	
Height of PV module array		2.0	3.0				1	m
Height of horizon	h_{Hori}	1.0	5.0				0	m
Distance of horizon	a_{Hori}	25.0	20.0				1000.0	m
Additional reduction factor shading	r_{other}	95%	90%				100%	
Efficiency of the inverter	η_{HRV}	95%	95%				95%	
Results								
Area of PV module array		55.1	27.2	0.0	0.0	0.0	5.4	m²
Free area on the selected building element		22.9	15.9				22.9	m²
Used fraction of building element		73%	63%				73%	
Annual losses due to shading		526	569				0	kWh

							Total	
Annual electricity yield after the inverter, absolute	**8575**	**2391**				**763**	**10966**	kWh/a
Referred to projected building footprint area	**106.0**	**29.5**				**9.4**	**136**	kWh/m²$A_{Projected}$*a
Specific PE factor (non-renewable primary energy)	0.47	0.55				0.5		kWh_{prim_ne}/kWh_{End}
Specific CO_2 equivalent emissions of the system	70.7	109.3				77.7		g/kWh
CO2-equivalent emissions according to 1-CO2 factors GEMIS (Germany)	1114.8	150.6				99.3	1265.4	kg/a
PE-factor according to 1-PE factors (non-renewable) PHI Certification	0.00	0.00				0.0	0.00	kWh_{prim}/kWh_{End}



End-of-terrace Passive House 156 m² treated floor area, Germany

Passive House with PHPP Version 10.3 EN

List of PV module technologies

	Technology	AEE kWh/Wp	CO_2 kg/Wp	Lifespan years	PER factor kWh/kWh	1-PE factors (non-renewable) PHI Certification kWh/kWh	1-CO2 factors GEMIS (Germany) kg/kWh
1							
2	Amorph-Si	7.955	1.141695	30	1.00	0.00	0.063
3	CIGS	5.805	0.788184	30	1.00	0.00	0.063
4	Mono-Si	11.85	1.782135	30	1.00	0.00	0.130
5	Poly-Si	8.04	1.595889	30	1.00	0.00	0.063

Unit 1

	Electricity	PER factor	PE	CO_2eq- emissions	
	Annual yield of inverter		1-PE factors (non-renewable) PHI Certification	1-CO2 factors GEMIS (Germany)	
Reduction		1.0	0.00	0.130	
Electricity generation	8575	8575	0.0	1115	kWh or kgCO_2-eq per year
spec. Electricity generation	106	106	0.0	14	kWh or kgCO_2-eq per year, per m² of floor space
PV module manufacture			0.5	71	kWh or g per kWh

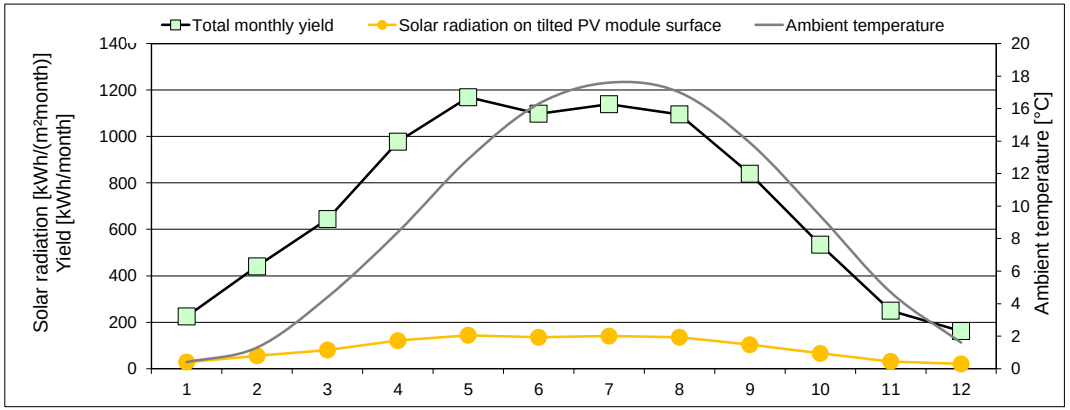
Information from the PV module data sheet

4-Mono-Si

Nominal current	I_{MPP0}	10.0	A
Nominal voltage	U_{MPP0}	34.0	V
Nominal power	P_n	340.0	Wp
Temperature coefficient short-circuit current	α	0.1	%/K
Temperature coefficient open-circuit voltage	β	-0.3	%/K

Further specifications

Latitude		51.3	°
Number of PV modules	n_M	30.0	
Deviation from North		180.0	°
Angle of inclination from horizontal		30.0	°
Height of PV module array		2.0	m
Height of horizon	h_{Hori}	1.0	m
Distance of horizon	a_{Hori}	25.0	m
Additional reduction factor shading	r_{other}	0.95	
Efficiency of the inverter	η_{HRV}	0.95	
Annual losses due to shading		526	kWh



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		Year	
Solar radiation on tilted PV module surface	28	55	80	121	144	135	140	135	103	66	31	20	kWh/(m²month)	1059.1	kWh/(m²a)
Ambient temperature	0	1	4	8	13	16	18	17	14	9	5	2	°C	9.0	°C
Total monthly yield	225	441	645	978	1169	1098	1139	1096	840	534	250	162	kWh/month	8575.4	kWh/a
Losses through shading situation	12	24	35	62	74	70	72	70	53	29	14	9	kWh/month	526.3	kWh/a

Electricity demand for residential buildings

Passive House with PHPP Version 10.3 EN

End-of-terrace Passive House / Climate: PHPP-Standard / TFA: 156 m² / Heating: 10.8 kWh/(m²a) / Cooling: 0.1 kWh/(m²a) / PER: 37.4 kWh/(m²a)

Number of dwelling units	1	DU
Number of occupants	2.9	P
Treated floor area A_{TFA}	156	m²

Solar fraction of DHW Laundry&Dish	52%
Marginal performance ratio DHW	24%
Marginal performance ratio Heating	57%

	PER factors	PE factors
Electricity	1.30	1.80
Energy carrier for DHW:	0.73	0.70
Energy carrier for space heating:	1.66	1.64
Gas for cooking, drying	1.75	0.00

Applications	Quantity	Consider for IHG?	Utilisation factor	Reference value		Frequency		In operation: Average power / electricity consumption of the application		Duration of use (h/app.)	Size of the unit		Useful energy (kWh/a)	When not in operation: Power (W)	Hours per unit (h/d)	Useful energy (kWh/a)	Total Useful energy (kWh/a)	Electricity demand: Electric fraction	Final energy (kWh/a)	Additional heating demand: Fraction additional demand	Additional/ reduced demand	Marginal expenditure	Solar fraction	Final energy (kWh/a)	PER demand (kWh/a)	PE demand (kWh/a)
Column no.	1	2	3	4	5	6		7		8	9		10	11	12	13	14	15	16	17	18	19	20	21	22	23
Refrigerating																										
Refrigerator	1	1	1.00	1	DU	365	d/a	0.28	kWh/d								102	100%	102						133	184
Freezer	1	0	0.90	1	DU	365	d/a	0.55	kWh/d								181	100%	181						235	325
Fridge-freezer combination	0	1	1.00	1	DU	365	d/a	0.61	kWh/d								0	100%	0						0	0
Cooking with:	1-Electricity																									
Electricity demand	1	1	1.00	2.9	P	500	/(P*a)	0.25	kWh/Use								369	100%	369						479	664
Gas demand																				0%				0	0	0
Dishwashing	1-DHW connection																									
Electricity demand	1	1	1.00	2.9	P	65	/(P*a)	0.95	kWh/Use	3.0	12	Place settings	182	0.75	22.4	6	188	50%	97						126	175
DHW demand																				50%	* 1.30	* 0.24	*(1- 0.52) =	14	10	10
Clothes washing	1-DHW connection							60%	Remaining moisture																	
Electricity demand	1	1	1.00	2.9	P	57	/(P*a)	0.79	kWh/Use	2.9	5	kg wash load	133	0.75	22.7	6	139	55%	79						103	143
DHW demand																				45%	* 1.05	* 0.24	*(1- 0.52) =	8	6	5
Drying with	1-Clothes line																									
Electricity demand	0	0	0.88	2.9	P	57	/(P*a)	2.13	kWh/Use	2.4	5	kg wash load	0	1.50	0.0	0	0	0%	0						0	0
Gas demand (for gas dryers)									kWh/Use								0			0%				0	0	0
Energy demand from evaporation	1	0	0.60	2.9	P	57	/(P*a)	0.00	kWh/Use								0			100%	* 1.00	* 0.57	*(1- 0.66) =	0	0	0
Lighting																										
Inside dwelling unit:	1	1	4.20	2.9	P	1.2	kh/(P*a)	14	W/lamp	50	lm/W (efficiency)		214				214	100%	214						278	385
Outside of dwelling unit:	0	1								Nominal illuminance:							0	100%	0						0	0

Other devices:	Quantity	IHG?	Reference value		Frequency		In operation				kWh/a	When not in operation: W	h/d	kWh/a	kWh/a	Electric fraction	Final energy	PER demand	PE demand
Small devices with rechargeable batteries (standard value)	1	1	2.9	P	365	d/a	0.03	kWh/(d*device)							36				
Router	1	1	1.0	DU	365	d/a	0.14	kWh/(d*device)							53				
TV	0.7	1	2.9	P	365	d/a	60	W	4.0	h/(d*P)	122.0	0.50	18.4	3	266				
Laptop	0.8	1	2.9	P	365	d/a	35	W	5.0	h/(d*P)	80.9	0.75	17.7	5	200				
Telephone	1	1	1.0	DU	365	d/a	3	W	3.0	h/(d*DU)	2.9	0.50	21.0	4	7				
Microwave oven / toaster	0.34	1	2.9	1-P	52	d/a	900	W	0.3	h/(d*P)	34.5	0.75	23.9	7	41				
Food processor / blender	1	1	1.0	2-DU	156	d/a	120	W	0.1	h/(d*DU)	1.6	0.00	24.0	0	2				
Vacuum cleaner	1	1	1.0	2-DU	52	d/a	750	W	0.5	h/(d*DU)	19.5	0.00	23.9	0	20				
		1	1.0			d/a		W		h/d	0.0		24.0	0	0				
		1	1.0			d/a		W		h/d	0.0		24.0	0	0				
		1	1.0			d/a		W		h/d	0.0		24.0	0	0				
		1	1.0			d/a		W		h/d	0.0		24.0	0	0				
		1	1.0			d/a		W		h/d	0.0		24.0	0	0				
		1	1.0			d/a		W		h/d	0.0		24.0	0	0				
		1	1.0			d/a		W		h/d	0.0		24.0	0	0				
		1	1.0			d/a		W		h/d	0.0		24.0	0	0				
		1	1.0			d/a		W		h/d	0.0		24.0	0	0				
		1	1.0			d/a		W		h/d	0.0		24.0	0	0				
								kWh/a							0				
								kWh/a							0				
								kWh/a							0				
Total other devices	1	1.00													622	100%	622	809	1120

			Final energy		PER	PE	
Total household electricity		kWh/a	**1665**	kWh/a	**2164**	**2996**	kWh/a
		kWh/(m²a)	**11**	kWh/(m²a)	**14**	**19**	kWh/(m²a)
Electricity demand for:							
Space heating	from 'PER' worksheet, without aux. electricity	kWh/a	1065	kWh/a	1917	1917	kWh/a
Cooling + dehumidification	from 'PER' worksheet, without aux. electricity	kWh/a	186	kWh/a	205	335	kWh/a
Domestic hot water	from 'PER' worksheet, without aux. electricity	kWh/a	685	kWh/a	890	1233	kWh/a
Aux Electricity	from 'Aux. Electricity' worksheet	kWh/a	727	kWh/a	1064	1308	kWh/a
Total sum electricity demand		kWh/a	**4327**	kWh/a	**6239**	**7789**	kWh/a
		kWh/(m²a)	**28**	kWh/(m²a)	**40**	**50**	kWh/(m²a)

Additional demand transferred to other worksheets:

DHW for washing machines and dishwashers	188	kWh/a
Additional space heating (energy demand from evaporation)	0	kWh/a
Gas demand for clothes drying / cooking	0	kWh/a

Aux Electricity

Passive House with PHPP Version 10.3 EN

End-of-terrace Passive House / Climate: PHPP-Standard / TFA: 156 m² / Heating: 10.8 kWh/(m²a) / Cooling: 0.1 kWh/(m²a) / PER: 37.4 kWh/(m²a)

Heating period	151	d/a	Vent. system on in winter	5.25	kh/a	Treated floor area	156	m²			
Cooling period	48	d/a	Vent. system on in summer	3.51	kh/a	Boiler design output	15	kW			
Dwelling units	1		Heat recovery efficiency ventilation	0.82		DHW system heat demand	2824	kWh/a			kWh/kWh
Volume of ventilated space	390	m³	Air change rate	0.30	h^{-1}	Design flow temperature	55	°C	PE factor for electricity	1.80	

Application	Used?	Consider for IHG?	Final energy demand: Norm demand or power		Utilisation factor		Period of operation	Reference value		Electricity demand	Internal heat gains (IHG): Availability	Utilisation period	Winter	Summer	PER: PER factor	PER demand	PE: PE demand
	[1/0]	[1/0]					kh/a			kWh/a		kh/a	W	W	kWh/kWh	kWh/a	kWh/a
Column no.	1	2	3		4		5	6		7	8	9	10	11	12	13	14
Heating, ventilation winter																	
Ventilation system																	
Ventilation in winter	1		0.40	Wh/m³	0.30	h^{-1}	5.25	390	m³	246	IHG included in heat recovery efficiency				1.80	442	442
Defroster HX	0	1	From worksheet 'Ventilation/Addl. Vent'							0	0.2	3.62	0		1.80	0	0
Heating system																	
Circulation pump heating	1	1	21	W	0.77		3.62			58	1.0	3.62	16		1.80	105	105
Regulated?	1		21	W user-defined pump nominal power													
Aux. energy - Heat. boiler	0	0	55	W	1.00		0.00			0	0.0	3.62	0		1.80	0	0
				W user-defined el. power at 30% load													
Aux. energy - wood-burning/pellet boiler	0	0	from 'Boiler' worksheet, incl. aux. energy for DHW							0	0.0	3.62	0		1.80	0	0
Fan coils		1		W	0.23		3.62			0	1.0	3.62	0		1.80	0	0
				kWh/a						0	0.0	3.62	0		1.80	0	0
				kWh/a						0	0.0	3.62	0		1.80	0	0
				kWh/a						0	0.0	3.62	0		1.80	0	0
				kWh/a						0	0.0	3.62	0		1.80	0	0
				kWh/a						0	0.0	3.62	0		1.80	0	0
Total aux. electricity heating, ventilation winter										304			16			548	548
Cooling, ventilation in summer			**Final energy demand**								**Internal heat gains (IHG)**				**PER**		**PE**
Ventilation system																	
Ventilation in summer	1		0.40	Wh/m³	0.30	h^{-1}	3.51	390	m³	164	IHG included in recovery efficiency for cooling				1.10	181	295
Additional vent. summer	1		x	Wh/m³	0.00	h^{-1}	3.51	390	m³	0	IHG included in the worksheets 'Summer' + 'Cooling'				1.10	0	0
Cooling system																	
Circulation pump cooling		1		W	0.0		1.2			0	1.0	1.2		0	1.10	0	0
Fan coils (recirculation cooling)		1		W	0.0		1.2			0	1.0	1.2		0	1.10	0	0
Cooling server rooms		0		kWh/a						0					1.10	0	0
				kWh/a						0	0.0	3.51		0	1.10	0	0
				kWh/a						0	0.0	3.51		0	1.10	0	0
				kWh/a						0	0.0	3.51		0	1.10	0	0
				kWh/a						0	0.0	3.51		0	1.10	0	0
				kWh/a						0	0.0	3.51		0	1.10	0	0
Total aux. electricity cooling, ventilation summer										164				0		181	295
Dehumidification			**Final energy demand**								**Internal heat gains**				**PER**		**PE**
				kWh/a						0	0.0	3.51		0	1.15	0	0
				kWh/a						0	0.0	3.51		0	1.15	0	0
				kWh/a						0	0.0	3.51		0	1.15	0	0
Total aux. electricity dehumidification										0				0		0	0
DHW system			**Final energy demand**								**Internal heat gains**				**PER**		**PE**
Circulation pump DHW	1	0	29	W			6.57	kh/a		188	0.0	8.76	0	0	1.30	244	338
				W user-defined nominal power of the pump													
Storage load pump DHW		0	56	W			1.10	kh/a		0	0.0	8.76	0	0	1.30	0	0
				W user-defined nominal power of the pump													
DHW boiler aux. energy	0	0	165	W			0.00	kh/a		0	0.0	8.76	0	0	1.30	0	0
				W user-defined nominal power of the pump													
Solar aux. electricity	1	0	40	W			1.75	kh/a		70	0.0	8.76	0	0	1.30	91	126
				W user-defined nominal power of the pump													
Total aux. electricity DHW+Solar										258			0	0		336	465
Other			**Final energy demand**								**Internal heat gains**				**PER**		**PE**
Inverter	1		47	W in winter			95	W in summer			0.0		0	0			
Elevator				kWh/a						0	0.0	8.76	0	0	1.30	0	0
				kWh/a						0	0.0	8.76	0	0	1.30	0	0
				kWh/a						0	0.0	8.76	0	0	1.30	0	0
				kWh/a						0	0.0	8.76	0	0	1.30	0	0
				kWh/a						0	0.0	8.76	0	0	1.30	0	0
Total aux. electricity other										0			0	0		0	0

	Winter	Summer	
Total internal heat gains	**16**	**0**	W
	0.1	**0.0**	W/m²

	Final energy		PER	PE
Total auxiliary electricity	**727**	kWh/a	**1064**	**1308**
	4.66	kWh/(m^2_{TFA} a)	**6.8**	**8.4**

Internal heat gains for residential buildings (IHG)

End-of-terrace Passive House / Climate: PHPP-Standard / TFA: 156 m² / Heating: 10.8 kWh/(m²a) / Cooling: 0.1 kWh/(m²a) / PER: 37.4 kWh/(m²a)

Number of occupants: 2.9 P
Treated floor area: 156 m²

Building use: 10-Residential building: Residential
Values used for IHG: 2-Standard
Link to drop-down list

	IHG winter	IHG summer	
No input necessary			
Used for energy balance:	**2.42**	**2.42**	W/m²

Application	Number / number of occupants		Consider for IHG?	Norm consumption		Utilisation factor	Frequency		Useful energy (kWh/a)		Included in electricity balance?	Availability		Utilisation period [kh/a]		**IHG winter [W]**	**IHG summer [W]**
Persons	3	P	1	80.0	W/P	1.00	8.76	kh/a	2067	*		0.55	/	8.76	=	130	130
Evaporation	3	P	1	-25.0	W/P	1.00	8.76	kh/a	-646	*		1.00	/	8.76	=	-74	-74
Refrigerator	1		1	0.3	kWh/d	1.00	365	d/a	102	*		1.00	/	8.76	=	12	12
Freezer	1		0	0.6	kWh/d	0.90	365	d/a	181	*		1.00	/	8.76	=	0	0
Fridge-freezer combination	0		1	0.6	kWh/d	1.00	365	d/a	0	*		1.00	/	8.76	=	0	0
Cooking	1		1	0.3	kWh/Use	1.00	500	/(P*a)	369	*		0.50	/	8.76	=	21	21
Dishwashing	1		1	1.0	kWh/Use	1.00	65	/(P*a)	188	*		0.30	/	8.76	=	6	6
Clothes washing	1		1	0.8	kWh/Use	1.00	57	/(P*a)	139	*		0.30	/	8.76	=	5	5
Drying with Clothes line	0		0	0.0	kWh/Use	0.88	57	/(P*a)	0	*		1.00	/	8.76	=	0	0
Gas demand (for gas dryers)			0	0.0	kWh/Use				0	*		0.80	/	8.76	=	0	0
Energy demand from evaporation															=	0	0
Lighting inside the thermal envelope	1		1	14.4	W	4.20	1.2	kh/(P*a)	214	*		1.00	/	8.76	=	24	24
Lighting outside the thermal envelope	0		1						0	*		1.00	/	8.76	=	0	0
Other devices (see 'Electricity' worksheet)	1		1.0						622	*		1	/	8.76	=	71	71
Auxiliary appliances (cf. 'Aux electricity' worksheet)															=	16	0
															=		
															=		

				Winter or Summer Power			Useful energy winter or summer				Utilisation period winter or summer						
DHW - circulation	1		1				299	173	kWh/a	/	5.25	or	3.51	=	57	49
DHW - individual pipes	1		1				55	32	kWh/a	/	5.25	or	3.51	=	11	9
DHW storage tank	1		0	0.0	0.0	W								=	0	0
Cold water	3	P	1	-20.4	-20.2	W/P								=	-60	-60

Internal heat gains (IHG)			
	219	**194**	W
	1.40	**1.25**	W/m²

Primary Energy Renewable PER

Passive House with PHPP Version 10.3 EN

End-of-terrace Passive House / Climate: PHPP-Standard / TFA: 156 m² / Heating: 10.8 kWh/(m²a) / Cooling: 0.1 kWh/(m²a) / PER: 37.4 kWh/(m²a)

Selection of the heat generation system	Contribution (useful energy) Heating	DHW
2-Wärmepumpe	100%	100%
-		
-		
-		
Additionally:		
Solar thermal	0.9	9.5 kWh/(m²a)

Building type:	4-Row house	
Treated floor area A_{TFA}:	156	m²
Projected building footprint $A_{Projected}$:	81	m²
Heating demand incl. distribution & hydr. frost protection	12.0	kWh/(m²a)
Cooling energy demand incl. dehumidification	0	kWh/(m²a)
DHW demand including distribution:	18.1	kWh/(m²a)
Biomass contingent (PER):	20	kWh/(m²a)

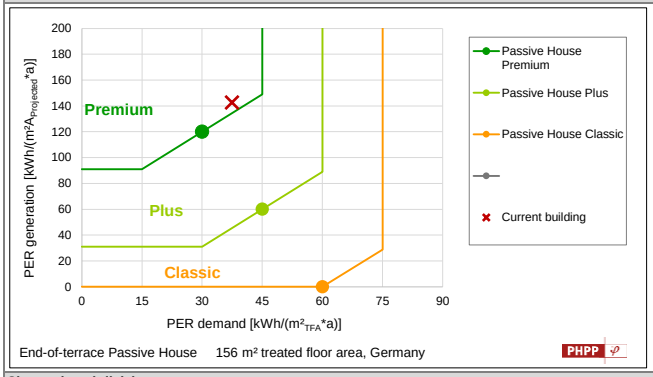
Energy demand referred to treated floor area	Efficiency Calculation -	Efficiency User defined -	Useful energy Covered fraction	Final energy demand kWh/(m²a)	PER factor kWh/kWh	PER demand kWh/(m²a)	PE factor kWh/kWh	PE demand kWh/(m²a)	CO_2 Emission factor (CO_2-eq) kg/kWh	CO_2 CO_2eq emissions kg/a
							1-PE factors (non-renewable) PHI Certification		1-CO2 factors GEMIS (Germany)	
Heating			100%							
Electricity (HP compact unit)					1.80		1.80		0.363	
Electricity (heat pump)	1.63		93%	6.8	1.80	12.3	1.80	12.3	0.363	386
Other (heating)					1.80		1.80		0.363	
Boiler					1.75		1.10		0.250	
District heating					0.98		0.30		0.000	
Solar thermal system			7%	0.9	0.26	0.2	0.00	0.0	0.045	6
Aux. electricity (heating, wintertime ventilation)				1.9	1.80	3.5	1.80	3.5	0.363	110
Total heating						**16.0**		**15.8**		**503**
Cooling and dehumidification					**PER**		**PE**		**CO_2**	
Electricity cooling (HP)	1.55			0.1	1.10	0.2	1.80	0.3	0.363	8.0
Electricity dehumidification (HP)					1.15		1.80		0.363	
Auxiliary electricity cooling, ventilation summer				1.1	1.10	1.2	1.80	1.9	0.363	59.6
Auxiliary electricity (dehumidification)					1.15		1.80		0.363	
Total cooling and dehumidification						**1.31**		**2.15**		**67.58**
DHW generation			100%		**PER**		**PE**		**CO_2**	
Electricity (HP compact unit)					1.30		1.80		0.363	
Electricity (heat pump)	1.96		48%	4.4	1.30	5.7	1.80	7.9	0.363	249
Electricity (direct)					1.30		1.80		0.363	
Boiler					1.75		1.10		0.250	
District heating					0.87		0.30		0.000	
Solar thermal system			52%	9.5	0.36	3.5	0.00	0.0	0.045	67
Aux. electricity (DHW + solar DHW)				1.7	1.30	2.2	1.80	3.0	0.363	94
Total DHW						**11.3**		**10.9**		**409**
Household electricity + Auxiliary electricity (other)					**PER**		**PE**		**CO_2**	
Household electricity (lighting, electrical devices, etc.)				10.7	1.30	13.9	1.80	19.2	0.363	604
Auxiliary electricity (other)					1.30		1.80		0.363	
Total household electricity and auxiliary electricity						**13.9**		**19.2**		**604**
Additional gas demand					**PER**		**PE**		**CO_2**	
Drying/Cooking				0.0	1.75	0.0	0.00	0.0	0.000	
Total additional gas demand						**0.00**		**0.00**		**0**
Total PER demand without bioenergy budget						**42.5**				
Bioenergy utilisation						**-5.1**				

The bioenergy budget will be used with 8.6 kWh/(m²a).

Total energy demand kWh/(m^2_{TFA} a)	**PER:**	**37.4**	**PE:**	**48.0**	**CO_2:**	**1584**	kg/a

Energy generation referred to projected building footprint	Final energy Final energy generation kWh/a	Final energy generation kWh/($m^2A_{Projected}$*a)	PER factor kWh/kWh	PER generation kWh/($m^2A_{Projected}$a)	PE factor kWh/kWh	PE generation kWh/($m^2A_{Projected}$a)	CO_2 Emission factor (CO_2-eq) kg/kWh	Emissions generated kg/a	Emissions saved kg/a
PV electricity	10966	135.5	1.00	135.5	0.00	0.0	0.115 I 0.363	1265	2715
Solar thermal system	1612	19.9	0.35	7.0	1.80	35.9	0.045 I 0.363	73	513
		0.0							
Total energy production kWh/($m^2_{Projected\ building\ footprint}$ a)		**PER:**	**142.54**	**PE:**	**35.87**	**CO_2:**	**1338**	**3228**	

Verification Passive House/EnerPHit standard



Classes in subdivisions:	Current value:			PHI Criteria Low Energy Building	Criteria Passive House : Classic	Plus	Premium	Achieved class
Heating demand referred to TFA	**11** kWh/(m²a)	≤	30		15			Premium
Heating load referred to TFA	**9** W/m²	≤	-		10			
Cooling and dehumidification demand referred to TFA	**0** kWh/(m²a)	≤	30		15			Premium
Airtightness n_{50}	**0.3** 1/h	≤	1		0.6			Premium
PER demand referred to TFA	**37** kWh/(m²a)	≤	75		60	45	30	Premium
PER generation referred to projected building footprint	**143** kWh/(m²a)	≥	-		0	60	120	
PE demand (non-renewable primary energy)	**48** kWh/(m²a)	≤	95			95		Classic
Energy standard of the whole building				**With the selected verification method PER (renewable) the following class can be reached:**				**Premium**

Standard criteria

Summary Different final energy sources are added up here. Though this is not scientifically correct, it is required by other single verifications.	**Final energy** MWh/a	**PER (renewable primary energy)** MWh/a	**PE (non-renewable primary energy)** 1-PE factors (non-renewable) PHI Certification MWh/a	**CO2eq emissions** 1-CO2 factors GEMIS (Germany) kg/a	**CO_2eq substitution** 1-CO2 factors GEMIS (Germany) kg/a
Demand	**5.8**	**5.8**	7.49	1584	1584
Generation	**-12.6**	**-11.5**	-2.90	1338	-3228
Cumulated demand and generation (annual balance)	**-6.80**	**-5.69**	4.59	2922	-1644
Demand without occupant electricity consumption	4.11	3.68	4.50	-92677	-92677
Demand without occupant electricity consumption, accumulated generation	-8.47	-7.86	1.59	-91339	-95905

Heat pump

Passive House with PHPP Version 10.3 EN

End-of-terrace Passive House / Climate: PHPP-Standard / TFA: 156 m² / Heating: 10.8 kWh/(m²a) / Cooling: 0.1 kWh/(m²a) / PER: 37.4 kWh/(m²a)

Building type: 4-Row house

Heating demand to be covered — Treated floor area A_{TFA}: 156 m²

Covered fraction of space heating demand		('PER' worksheet)	93%	
Space heating demand + distribution losses	Q_H+Q_{HL}:	(DHW+Distribution)	1871	kWh/a
Solar fraction for space heat	$\eta_{Solar,\ H}$	('SolarDHW' worksheet)	7%	
Effective annual heating demand	$Q_{H,WI}=Q_H*(1-\eta_{Solar,\ H})$		**1739**	**kWh/a**
Covered fraction of DHW demand		('PER' worksheet)	100%	
Total heating demand of the DHW system (without storage losses)	Q_{gDHW}	(DHW+Distribution)	2824	kWh/a
Solar fraction for DHW	$\eta_{Solar,\ DHW}$	('SolarDHW' worksheet)	52%	
Effective DHW demand	$Q_{DHW,WI}=Q_{DHW}*(1-\eta_{Solar,\ DHW})$		**1345**	**kWh/a**
Nominal power of distribution system	P_{nom}		1.38	kW

Space heating

x **Water-based heating with HP (according to EN 14825 / EN 14511, heating HP)**

Selection of the heat pump: 96ud-Standard air/water heat pump — Go to list of HPs according to EN 14825 / EN 14511

1-Sorting: AS LIST

Heat source			1-Outdoor air	
Selection of heat emission			3-Supply air heating	
Design distribution temperature	θ_{design}	(DHW+Distribution)	55	
Heat pump control strategy			1-On/Off	
Heat storage tank (buffer storage tank 'DHW+Distribution' worksheet)			0-No	
Location of buffer storage			1-Inside	
Temperature in installation room of storage tank (inside thermal envelope)		(DHW+Distribution)		°C
Specific heat losses storage	U * $A_{Storage}$			W/K
Sink temperature of heat pump for heating			62	°C

Detailed information (to be filled in by experts only)

Nominal power of distribution system	P_{nom}		kW
Radiator exponent	n		

Ground: no input necessary here

Depth ground water / Ground collector / Ground probe	z		m
Power of pump for ground heat exchanger	P_{pump}		kW

Air to air HP (according to EN 14825 / EN 14511)

Number of units

Unit selection — Go to list of HPs according to EN 14825 / EN 14511

1-Sorting: AS LIST

Heat source	
Heating system	
Heat pump control strategy	
Silent mode	
Supplementary heating available	

Combined ventilation unit with HP or split unit

Number of units

Unit selection — Go to list of combined ventilation/split units

1-Sorting: AS LIST

Heat pump with ventilation function

DHW generation

Type of backup heater		1-Elec. immersion heater	
Δθ of electric continuous flow water heater		0.0	K

x **With HP for heating (see above for details)**

Same sink temperature for heating and DHW		1-Yes	
Heat pump priority	(Manufacturer, tech. data)	1-DHW priority	

Separate HP for DHW

Unit selection — Go to list of HPs according to EN 14825 / EN 14511

1-Sorting: AS LIST

Heat source				
DHW temperature		(DHW+Distribution)	60	°C
Location of DHW storage tank ('storage 1' in 'DHW+Distribution' worksheet)			2-Outside	
Specific heat losses storage	U * $A_{Storage}$		0.9	W/K
Temperature in the installation room of storage tank (inside thermal envelope)		(DHW+Distribution)	11	°C

No input necessary here

Depth ground water / Ground collector / Ground probe	z		m
Power of pump for ground heat exchanger	P_{pump}		kW

Results

Electrical energy consumption pump (ground water / brine)	$Q_{El,Pump}$		0	kWh/a
Electricity demand for heat supply direct electric	$Q_{El,dir}$		0	kWh/a
Electrical consumption of HP	Qel_{HP}		1750	kWh/a

		without storage losses	with storage losses	
Space heat supplied by HP	$Q_{HP,Heating}$	1739	1739	kWh/a
Winter DHW supplied by HP	$Q_{HP,DHW,Winter}$	752	872	kWh/a
Summer DHW supplied by HP	$Q_{HP,DHW,Summer}$	206	473	kWh/a

		1st HP: Heating + DHW	2nd HP: -
Seasonal performance factor of heat pump	SPF_{H-1}	**1.76**	
Seasonal performance factor system	SPF_{H-3}	**1.76**	

Performance ratio of heat generator, DHW & space heating **57%**

Final electrical energy demand heat generation	Q_{final}	1750	kWh/a	11.2	kWh/(m²a)
Annual PER demand (renewable primary energy)		2807	kWh/a	18.0	kWh/(m²a)
Annual PE demand (non-renewable primary energy)		3149	kWh/a	20.2	kWh/(m²a)
Annual CO_2-equivalent emissions		635	kg/a	4.1	kg/(m²a)

HP for heating and DHW — **HP is in use**

Selection: Standard air/water heat pump

Source: 1-Outdoor air

Sink: 2-Water

cted heating system

	θ_source °C	θ_sink °C	Heating capacity kW	COP
Test point 1	-7.0	35.0	2.2	2.7
Test point 2	2.0	35.0	2.6	3.1
Test point 3	10.0	35.0	3.1	4.0
Test point 4	15.0	35.0	3.8	4.3
Test point 5	-7.0	50.0	2.0	2.0
Test point 6	2.0	50.0	2.5	2.3
Test point 7	7.0	50.0	3.0	2.8
Test point 8	15.0	50.0	3.7	3.3

Max. heating capacity	-20.0	35.0		Cycle limit [-]
Max. heating capacity	-20.0	55.0		Part load coefficient Cc [-]
Max. heating capacity	-10.0	35.0		Surface sump heater [W]
Max. heating capacity	-10.0	55.0		Standby Power [W]
Temperature difference in sink Δθ		5.0		

Air to air Heat pump — **Not active**

Select

Source: 1-Outdoor air

Sink: 1-Indoor air

	θ_source °C	θ_sink °C	Heating capacity kW	COP
Test point 1				
Test point 2				
Test point 3				
Test point 4				
Test point 5				
Test point 6				
Test point 7				
Test point 8				

Ventilation system with heat pump — **Not active**

Select

Source: 1-Outdoor air

Sink: 1-Room air

	θ_source °C	θ_sink °C	Heating capacity kW	COP
Test point 1- maximum				
Test point 1- ON/OFF limit				
Test point 2- Maximum				
Test point 2- ON/OFF limit				
Test point 3- Maximum				
Test point 3- ON/OFF limit				
Test point 4- Maximum				
Test point 4- ON/OFF limit				
Test point 5- Maximum				
Test point 5- ON/OFF limit				

Hot drinking water production - Heat pump — **Not active**

Selection: Standard air/water heat pump

Source: 1-Outdoor air

Sink: 2-Water

	θ_source °C	θ_sink °C	Heating capacity kW	COP
Test point 1	-7.0	35.0	2.2	2.7
Test point 2	2.0	35.0	2.6	3.1
Test point 3	10.0	35.0	3.1	4.0
Test point 4	15.0	35.0	3.8	4.3
Test point 5	-7.0	50.0	2.0	2.0
Test point 6	2.0	50.0	2.5	2.3
Test point 7	7.0	50.0	3.0	2.8
Test point 8	15.0	50.0	3.7	3.3

Max. heating capacity	-20	35	
Max. heating capacity	-20	55	
Max. heating capacity	-10	35	
Max. heating capacity	-10	55	
Temperature difference in sink Δθ		5.0	