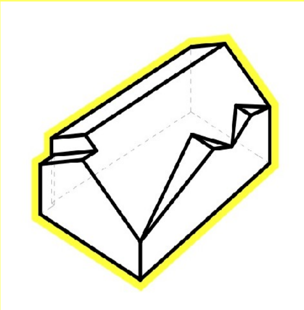


INTEGRATED ENERGY DESIGN
ASSIGNMENT 3
TEAM 2: Pablo Alarco Gonzalez, Isabelle Davoult, Alise Plavina

Table of contents

Introduction

The aim of this report is to provide a more detailed energy performance analysis for the Linesoya environmental project, along with specifications of the systems used, quality contro plan and operation strategies for the building.

In the **final design** part of the report, the main concepts and strategies used in the Linesoya design are summarized. These strategies have a direct impact on the energy efficiency of the building.

For the **energy performance** of the building an updated, manually calculated energy budget is provided, as well as a more detailed calculation performed with the Passive House Planning Package (PHPP) program. The manual calculation corresponds with the Norwegian Passivhus standard NS3700, while the PHPP program is based on the requirements set by the Passivhaus centre in Germany. Thus the results of these two calculations can be seen as comparative to a certain degree, but not producing identical results.

Due to the limited scope of this assignment, the **quality control plan**, **commissioning and monitoring plan**, as well as the **construction and operation strategies** are provided in a exemplary manner, providing some important aspects, but not a full report on all materials, components and systems included in the project.

1. Final design

The Linesoya design was aiming at fulfilling the Norwegian Passive house (passivhus) standart NS3700 and also including energy production possibilities on site or integrated within the building to reach a net-zero energy balance on a yearly basis. The set aims have been reached by following a number of design and energy efficiency strategies:

1. Compactness: in order to reduce the heat losses toward the exterior and optimize the functional use of the building
2. Buffer zone in the north: protect the primary living spaces and work as an extra insulation as the north facade receive less solar gain
3. Reduced northern glazed area (for the added volume): according to Ecotect analysis for Assignment 2 – the most efficient strategy to reduce heat loss of the thermal envelope
4. Thermal separation: double doors in the entrance + interior doors according to the functional layout
5. Optimized glazing from south: an asset for the solar heat gains in winter and daylight for primary spaces, shading device protected from the weather impact
6. Centralized service core: optimized and reduced ducts length and thus also thermal losses
7. External insulation: better way to avoid thermal bridges, insulates both the living spaces and the buffer zone, U-values lower than required by the NS3700
8. Cross ventilation: to reduce overheating during summer
9. Production of electricity and DHW on site: production of electricity with wind turbines (peak efficiency in winter) and PV panels (peak efficiency in summer) and production of domestic hot water with solar thermal panels
10. Minimized thermal bridges & airtightness

1.1 Heat loss factor

Since the design involves refurbishment of an existing building, special attention was paid to the methods of improving the existing thermal performance of the envelope. As the heat loss factor calculation shows, the thermal envelope performs within the limits set by the NS3700 (0,44 < 0,5 as set by the standard).

	U-value	Area	Heated Area	H	Heat loss factor H´´ (W/(m2K))
Wall	0,1	461	472	46,1	0,097669492
Roof	0,1	279,8	472	27,98	0,059279661
Floor	0,1	248	472	24,8	0,052542373
Windows and doors	0,7	65,4	472	45,78	0,096991525
Thermal Bridges *	0,03	472	1	14,16	0,03
Infiltration			472	31,78	0,067330508
Ventilation			472	18,71	0,039639831
Sum heat loss factor					0,44345339

*** Coefficient = 0,03 (NS 3031)**

1.2 Updated energy budget

a) Net energy demand

	kWh/a
HEATING DEMAND	14 496, 51
Space heating	6 539, 55
Domestic hot water	7 956, 95

	kWh/a
ELECTRICITY DEMAND	6 808, 81
Lighting	2 136, 09
Equipment	4 672, 71

Details of the calculations

	kWh/(m²a)	residential	kWh/(m²a)	cultural	kWh/a
Heating	15	105,4	13,5	367,3	6539,55
DHW	29,8	105,4	13,112	367,3	7956,9576
Lighting	8	105,4	3,52	367,3	2136,096
Equipment	17,5	105,4	7,7	367,3	4672,71
				TOTAL:	21305,3136

b) Delivered energy

	kWh/a
ELECTRICITY PRODUCTION	11.838
Wind turbines	9.438
PV	2.400

→

	kWh/a
Lighting	2136,09
Equipment	4672,71
Use of heat pump	4363,59
Use of Solar panels	501,25

	kWh/a
HEATING PRODUCTION	14496,51
Heat pump	10 210, 81
Solar panels	4 285, 7
TOTAL:	26.335

→

	kWh/a
Space heating	6539,55
Domestic hot water	7956,95
TOTAL:	26170,14

c) Energy balance

HEATING		ELECTRICITY	
space heating	-6539,55	Lighting	-2136,09
DHW	-7956,95	Equipment	-4672,71
Solar panels	4285,7	Use of heat pump	-4262,59
Heat pump	10210,8	Use of Solar panels	-501,25
		Wind turbines	9438
		PV	2400
Balance	0		265,36

The electricity production is more than the electricity demand for the house. It will be used for the electric cars. With 265, 36 kWh/a, an electric car can run 63 km during 6 months of the year. In case of an increased electric car use on Linesoya, additional electricity production can be considered.

1.3 Technologic solutions for delivered energy:

a) Electricity production - PV - reference:

Producer: SOLARWATT

Type: Building Integrated PV

Product: M250-60 GET LK Black, dimension: 1674*954*5mm (1, 65 m²), Peak power: 250 Wp, 151Wp/m²

Simulation of the average output in PVGIS Sunbird in Linesoya, facing south, 27° slope: **22m²** of PV produce **2400 kWh/a**

b) Electricity production - Wind turbine – reference:

Producer: HELIX WIND

Type: Vertical axis wind turbine

Product: S322

Average annual output (according to producer): 1573 kWh for an average wind speed of 6,5m/s. According to Orlandet weather station (nearest to Linesoya) the average wind speed in the region is 12 knots (see image below), which is comparable to the 6,5 m/s.

6 wind turbines, placed on the south east side of the site will produce **9438 kWh/a**

Orlandet (ORLANDET)
Statistics based on observations taken between 9/2002 - 2/2011 daily from 7am to 7pm local time.

Month of year	Jan 01	Feb 02	Mar 03	Apr 04	May 05	Jun 06	Jul 07	Aug 08	Sep 09	Oct 10	Nov 11	Dec 12	SUM 1-12
Dominant Wind dir.													
Wind probability > = 4 Beaufort (%)	76	67	59	54	45	37	31	27	47	58	69	73	**53**
Average Wind speed (Knots)	17	14	13	12	11	10	9	9	12	13	15	15	**12**
Average air temp. (°C)	2	1	3	8	11	13	16	16	12	8	4	2	**8**
Select month (Help)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year

c) DHW production Solar collectors-reference:

Producer: Suntech

Type: Roof integrated

Product: MSZ-195J-D*, dimension: 1621*841*33 (1,36m²),

Peak power: 195 Wp, 143, 4 Wp/m²

Simulation: none. Reference taken: the Linesoya case study: **10m²** of solar collectors to produce **4285, 7 kWh/a.** Heat pump: The remaining domestic hot water will be produced by the heat pump, i.e. 3671, 26 kWh/a

d) Space heating and DHW production - Heat pump:

Reference for the COP of 2, 34: lecture of Energy calculations, table B.9

The heat pump will produce most of the space heating, at the coldest periods, so approx. **6539, 55 kWh/a.** A heat recovery ventilator will be used as space heater during the mid-periods (autumn and spring).

2. Performance report according to PHPP

Our team decided to use PHPP for energy performance analysis of the Linesoya design according to standards and input value used in the program, and not trying to adjust to Norwegian NS 3700 to avoid the mix of different inputs and produce unreliable results. Some of the differences observed between the values in NS3700 and those required in PHPP are included in the "PHPP input data" section.

2.1 PHPP input data:

Climate data – N-Oslo, in-built climate data in PHPP
Interior temperature - **20°C**, according to PHPP requirements (NS3700 – 21°C)
Overheating limit – **25°C** (not regimented in the NS3700)
Number of persons: 13,9 (calculated with min for PHPP verification - 35m^2/per person)

Treated floor area – calculated differently from Norwegian BRA - instead of 472 m^2, the floor are used in PHPP was calculated to be **486 m²** (excluding walls, some space underneath stairs etc). According to the calculation method, the 60% of the unheated attic area was also included in the treated floor area, since the attic is within the thermal envelope.
Walls – separating the areas of walls open to the ambient air and those to the ground.
U-values – using the roof, wall and floor layering as proposed in the details for the design, however the PHPP calculated U-values are 1-2% lower than the ones proposed in the design.
Windows – windows with improved g-value given in the PHPP program were used (NorDan 0.370, PHPP Triple-low-e Kr12 – 0.500) and U-value (0.7 vs 0.58) that resulted in more balanced solar gains and losses on annual basis. The entrance doors are included in the windows schedule.

Thermal bridges – were not included to simplify the calculations, assuming careful detailing minimizing their impact on the thermal performance of the building.
Air tightness – 0,5 h^{-1} (complying with both PHPP and NS3700 requirements < 0,6 h^{-1})
Room height – max advised room height to be used in the PHPP calculations is **2.5 m,** that results in a smaller building volume, enclosed volume V_e = 1960 m^3 , while the room ventilation volume that takes into account the room height is only **V_v = 1215 m³**
Internal heat gains – 2,1 W/ m^2 (given in PHPP as the value for dwelling internal gains)

Electricity demand – mostly using the appliances proposed in the example, changing only "cooking with gas" to "cooking with electricity"
Auxiliary electricity – mostly using the values provided in the example, changing only the position of pumps for heating and DHW to "within the thermal envelope"
Heat pump – 100% covered fraction of heating demand, 45% of DHW (55% by solar thermal)
Solar DHW – the area of solar thermal collectors was increased from 10 to 15 m^2 to cover the summer demand for DHW for the 13,9 people (min possible according to PHPP). The original design assumed a much smaller number of inhabitants, thus the 10 m^2 solar thermal panel area was sufficient.
Heating recovery efficiency – **90%** (required in the NS3700 > 80%)
!! On-site electricity production – the electricity produced by both 22 m^2 of PV panels and the six wind turbines of the original design are used. Although PHPP provides the space to account only for solar electricity (no wind power), it was decided to include to wind turbines to evaluate the overall energy conservation value from renewable sources.

2.2 PHPP results:

General verification

Specific Demands with Reference to the Treated Floor Area				
Treated Floor Area:	486,0	m²		
	Applied:	Annual Method	PH Certificate:	Fulfilled?
Specific Space Heat Demand:	15	kWh/(m²a)	15 kWh/(m²a)	Yes
Pressurization Test Result:	0,5	h^{-1}	0,6 h^{-1}	Yes
Specific Primary Energy Demand (DHW, Heating, Cooling, Auxiliary and Household Electricity):	62	kWh/(m²a)	120 kWh/(m²a)	Yes
Specific Primary Energy Demand (DHW, Heating and Auxiliary Electricity):	31	kWh/(m²a)		
Specific Primary Energy Demand Energy Conservation by Solar Electricity:	49	kWh/(m²a)		
Heating Load:	11	W/m²		
Frequency of Overheating:		%	over 25 °C	
Specific Useful Cooling Energy Demand:	0	kWh/(m²a)	15 kWh/(m²a)	Yes
Cooling Load:	4	W/m²		

Areas and determination and U-values

Total thermal envelope – 1054,06 m²

Average U-value for thermal envelope – 0,129 W/(m²K)

Building components with largest fractions of transmission heat losses are south-facing windows – 19%, due to the large surface area (for comparison windows in north 6%, east 9%, west 2%).

Windows and solar radiation

Transmission losses – 4654 kWh/a

Solar radiation heat gains – 4712 kWh/a

Only south-facing windows show larger solar gains (3714 kWh/a) than transmission losses (2428 kWh/a). The worst balance is for the north-facing windows – 171 kWh/a solar gains and 758 kWh/a transmission losses.

The double window casement system in the south with the possibility of pre-heating the incoming air was not considered in PHPP calculations, since without dynamic analysis its performance efficiency cannot be evaluated. At the same time assuming a window with quadruple glazing lowers the g-value of the glazing system and results in lower solar gains, which are not compensated for with the improved U-value. Thus it was decided to use triple glazed windows for the PHPP calculation.

Specific space heating load

Annual Heating demand: **15,1 kWh/(m²*a)** used in PHPP verification

Monthly heating demand: **15,3 kWh/(m²*a)** according to EN 13790

Additional heating necessary – not enough with supply air heating.

Heating load (clear, cold day, T= -13,5°C) P_H = 5562 W, while heating load transportable by air $P_{Supply\ Air,\ Max}$ = 4032 W. Without supplementary heating, supply air temperature would be 18,5°C. However, the specific heating load is 11,4 W/m² (is slightly above the advised 10 W/m²) and will occur in very rare cases for which portable electric heating devices can be provided.

Ventilation

Design air flow rate max – 474m³/h

Average air flow rate – 365 m³/h

Guaranteed min air change rate – 0,30 1/h

To reach the required specific space heat demand, the air change rate at pressurizing test was changed from 0,6 to 0,5 1/h, and the heat recovery system efficiency was increased from 83 to 90%.

Summer overheating and shading

Frequency of overheating, T > 25°C: **0 %** (< 10%, acceptable without additional measures)

Cooling demand: **0 kWh/(m²*a)** (< 15, acceptable)

Specific cooling load: 4,5 W/m²

The daily temperature swing due to solar load: 1,1 K (< 3K, acceptable)

Single-sided ventilation for windows in the south, north-south cross ventilation during the night.

Shading in summer; temporary shading reduction factor z: south windows 50%, all other windows 90%

Solar DHW

Solar thermal collector area, covering 62% of DHW demand (reaching near 100% in spring/summer), DHW requirements calculated for 13.9 persons: **15 m²**

Household electricity demand

Specific household electricity demand: **12,7 kWh/(m²*a)** (< 18, acceptable)

Specific household primary energy demand: **35,7 kWh/(m²*a)** (< 50, acceptable)

Primary energy values and CO_2

Total primary energy (PE) value: 61,9 kWh/(m²*a) (< 120, acceptable)

Total emissions CO_2 – equivalent: 15,6 kg/(m²*a)

PE value: conservation by solar electricity*: **48,7 kWh/(m²*a)**

CO_2 – emissions avoided due to solar electricity: **4,3 kg/(m²*a)**

*The electricity produced by wind turbines (as in the original design) is also included in this calculation.

3. Quality control plan

The quality control plan includes the requirements and values reached for the original design after the PHPP simulation according to reference building standards – Norwegian NS3700 and the German Passive House Standard.

Goals and requirements	Value reached	Solutions proposed by the design team
1 NS3700		
Annual space heating demand < 17,52 kWh/m²år	15 kWh/m²år	
U-value floor < 0,15W/(m2·K)	0,082 W/(m2·K)	Increased insulation thickness
U-value wall < 0,15W/(m2·K)	0,092 W/(m2·K)	Increased insulation thickness
U-value roof <0,13W/(m2·K)	0,092 W/(m2·K)	Increased insulation thickness
U-value windows < 0,80 W/(m2·K)	0,7 W/(m2·K)	Triple glazing with argon infill
U-value doors < 0,80 W/(m2·K)	0,7 W/(m2·K)	
System efficiency heat recovery >80%	90,00%	
Airtightness n50 <0.6ACH	0,5 ACH	
Efficient lighting and equipment	-	Use of efficient equipment and LED lighting
Minimized thermal bridges <0.03 W/mK	0,03 W/mK	Thermal bridge-free contruction principles
Heat loss coefficient <0.5	0,44	Reduced heat overall heat losses
2 PHPP-German Passive House Standard		
Annual space heating demand < 15 kWh/m²år	15 kWh/m²år	
Primary energy demand ≤ 120 kWh/m²år	62 kWh/m²år	
Airtightness n50 <0,6ACH	0,5 ACH	
Use of daylight	DF>1% in all plan	Good daylight factor distribution
Compact building form	-	Increased compactness
Efficient equipment and lighting	-	Use of efficient equipment and LED lighting
Space cooling = 0	-	Use of natural ventilation

4. Commissioning and monitoring plan

Commissioning and monitoring plan includes a list of building elements and systems used to achieve the verification of the Linesoya design as a “passive house” according to PHPP. Using these values and system requirements as guidelines in the further development is advisable.

Building element or system	Values set by design	Comments
1 Thermal envelope		
1.1 Walls		
1.1.1 Walls to ambient air	U-value < 0,093 W/(m²·K)	370 mm rockwool
1.1.2 Walls to ground	U-value < 0,082 W/(m²·K)	380 mm foamglass
1.3 Roof	U-value < 0,092 W/(m²·K)	400 mm rockwool
1.4 Basement floor	U-value < 0,089 W/(m²·K)	380 mm foamglass + 50 mm rockwool
1.5 Windows		
1.5.1 Window glazing	U-value < 0,58 W/(m²·K)	triple glazing, low-e, krypton filling
1.5.1 Window frame	U-value < 0,59 W/(m²·K)	PU frames with wooden finish
1.5.2 Window g-value	> 0,5	frame width 0.14 – 0.18 m
1.6 Shading		
1.6.1 Temporary reduction factor – S	< 50%	To be used in summer to avoid overheating
1.6.2. Temporary reduction factor – W, E	< 90%	To be used in summer to avoid overheating
2 Systems		
2.1 Ventilation system		
2.1.1 Heat recovery unit efficiency	> 90%	
2.1.2 Space heating load by ventilation air	< 5562 W	Additional heating necessary
2.1.3 Additional heating system	Approx. 1.5 kW power	Covered by portable heat sources
2.1.4 Space cooling load	< 2176 W	Used in summer
2.2 DHW		
2.2.1 Solar DHW fraction	> 60%	Vacuum tube collector
2.3 Heat pump	COP > 3.2	
3 Appliances		
3.1 Dishwasher		DHW connection
3.2 Washing machine		DHW connection
3.3 Refrigerator	Total specific electricity demand < 12,7 kWh/ (m²a)	
3.4 Cooking unit		Electric cooker
3.5 Lighting		Percentage of energy saving lighting > 80%
3.6 Consumer electronics		
3.7 Small appliances		

5. Construction and operation strategies

a) construction strategies:

- following the requirements and reference values provided by the design
- using the materials and building elements specified in the design or analogous
- ensuring thermal-bridge-free construction, minimizing the thermal bridge for foundations
- ensuring air-tightness and performing blower-door test (repeating until the required air change value is reached)

b) operation strategies:

- decreasing overall heating demand by lowering the heating in the buffer zone, and ensuring set-back temperatures for the primary spaces, when not used or during night
- decreasing electricity demand by using A or higher class appliances
- using energy saving lighting
- using shading and natural ventilation (opening windows) during summer to avoid overheating + avoiding using natural ventilation during the heating season

Conclusions

Due to the relatively large area, especially in south, the critical building element for the Linesoya building proved to be the windows – the U-values of glazing and frames and also their g-value, which had to be improved if compared to the original design. Other building elements remained as proposed by the design. South windows showed most transmission losses (19% of all), but the annual solar gains compensated for that.
The significance of natural ventilation in summer proved to be more important than shading reduction factors in minimizing the cooling load and overheating.

Other important aspects that had a relatively huge impact on the energy consumption of the building were those linked to infiltration air change rate (airtightness and site conditions in regard to ventilation – especially “wind protection coefficient, e”, according to EN 13790).

Similarly as the manual calculations based on NS 3700, PHPP is based on several assumptions that do not necessarily comply with the specificity of the Linesoya project. Calculating it fully as a dwelling for verification purposes 13.9 people have to used as the reference for the number of residents (max 35 m^2 per person). This number is later used to estimate the requirements for DHW and supply air requirements, thus leading to overestimated demand if compared to the actual use of building.

Passive House Verification

Building:	LIPA Environmental centre	
Location and Climate:	Linesoya	N - Oslo
Street:		
Postcode/City:		
Country:	Norway	
Building Type:	Dwelling	
Home Owner(s) / Client(s):		
Street:		
Postcode/City:		
Architect:	Group 2	
Street:		
Postcode/City:		
Mechanical System:		
Street:		
Postcode/City:		

Year of Construction:	2012				
Number of Dwelling Units:	1		Interior Temperature:	20,0	°C
Enclosed Volume V_e:	1960,0	m³	Internal Heat Gains:	2,1	W/m²
Number of Occupants:	13,9				

Specific Demands with Reference to the Treated Floor Area

Treated Floor Area: 486,0 m²

	Applied:	Annual Method		PH Certificate:	Fulfilled?
Specific Space Heat Demand:	**15**	**kWh/(m²a)**		**15 kWh/(m²a)**	**Yes**
Pressurization Test Result:	**0,5**	**h⁻¹**		0,6 h⁻¹	**Yes**
Specific Primary Energy Demand (DHW, Heating, Cooling, Auxiliary and Household Electricity):	**62**	**kWh/(m²a)**		120 kWh/(m²a)	**Yes**
Specific Primary Energy Demand (DHW, Heating and Auxiliary Electricity):	**31**	**kWh/(m²a)**			
Specific Primary Energy Demand Energy Conservation by Solar Electricity:	**49**	**kWh/(m²a)**			
Heating Load:	**11**	**W/m²**			
Frequency of Overheating:		**%**	over	25 °C	
Specific Useful Cooling Energy Demand:	**0**	**kWh/(m²a)**		15 kWh/(m²a)	**Yes**
Cooling Load:	**4**	**W/m²**			

We confirm that the values given herein have been determined following the PHPP methodology and based on the characteristic values of the building. The calculations with PHPP are attached to this application.

Issued on:

signed:

Passive House Planning

AREAS DETERMINATION

Building: LIPA Environmental centre   Heat Demand 15 kWh/(m²a)

Summary						Building Element Overview	Average U-Value [W/(m²K)]
Group Nr.	Area Group	Temp Zone	Area	Unit	Comments		
1	**Treated Floor Area**		**486,00**	m²	*Living area or useful area within the thermal envelope*		
2	**North Windows**	**A**	**10,50**	m²	Results are from the Windows worksheet.	**North Windows**	**0,697**
3	**East Windows**	**A**	**17,19**	m²		**East Windows**	**0,662**
4	**South Windows**	**A**	**33,91**	m²		**South Windows**	**0,691**
5	**West Windows**	**A**	**3,84**	m²		**West Windows**	**0,730**
6	**Horizontal Windows**	**A**	**0,00**	m²		**Horizontal Windows**	
7	**Exterior Door**	**A**	**0,00**	m²	*Please subtract area of door from respective building element*	**Exterior Door**	
8	**Exterior Wall - Ambient**	**A**	**383,25**	m²	*Window areas are subtracted from the individual areas specified in the "Windows" worksheet.*	**Exterior Wall - Ambient**	**0,092**
9	**Exterior Wall - Ground**	**B**	**77,88**	m²	*Temperature Zone "A" is ambient air.*	**Exterior Wall - Ground**	**0,100**
10	**Roof/Ceiling - Ambient**	**A**	**279,72**	m²	*Temperature zone "B" is the ground.*	**Roof/Ceiling - Ambient**	**0,092**
11	**Floor Slab**	**B**	**247,77**	m²		**Floor Slab**	**0,089**
12			**0,00**	m²	*Temperature zones "A", "B","P" and "X" may be used. NOT "I"*		
13			**0,00**	m²	*Temperature zones "A", "B","P" and "X" may be used. NOT "I"* Factor for X		
14		**X**	**0,00**	m²	*Temperature zone "X": Please provide user-defined reduction factor (0 < f, < 1):* 75%		
						Thermal Bridge Overview	**Ψ [W/(mK)]**
15	**Thermal Bridges Ambient**	**A**	**0,00**	m	*Units in m*	**Thermal Bridges Ambient**	
16	**Perimeter Thermal Bridges**	**P**	**0,00**	m	*Units in m; temperature zone "P" is perimeter (see Ground worksheet).*	**Perimeter Thermal Bridges**	
17	**Thermal Bridges Floor Slab**	**B**	**0,00**	m	*Units in m*	**Thermal Bridges Floor Slab**	
18	**Partition Wall to Neighbour**	**I**	**0,00**	m²	*No heat losses, only considered for the heat load calculation.*	**Partition Wall to Neighbour**	
Total Thermal Envelope			**1054,06**	**m²**		**Average Therm. Envelope**	**0,129**

Area Input																	Selection of the Corresponding Building Element Assembly	Nr.	U-Value [W/(m²K)]
Area Nr.	Building Element Description	Group Nr.	Assigned to Group	Quantity	x (	a [m]	x	b [m]	+	User-Determined [m²]	-	User Subtraction [m²]	-	Subtraction Window Areas [m²]	) =	Area [m²]			
	Treated Floor Area	1	Treated Floor Area	1	x (		x		+	486,00	-				) =	486,0			
	North Windows	2	North Windows	Please complete in Windows worksheet only!												10,5	From Windows sheet		0,697
	East Windows	3	East Windows													17,2	From Windows sheet		0,662
	South Windows	4	South Windows													33,9	From Windows sheet		0,691
	West Windows	5	West Windows													3,8	From Windows sheet		0,730
	Horizontal Windows	6	Horizontal Windows													0,0	From Windows sheet		0,000
	Exterior Door	7	Exterior Door		x (		x		+		-		) -		=		U-Value Exterior Door		
1	Exterior wall south	8	Exterior Wall - Ambient	1	x (	21,65	x	5,85	+		-		) -	33,9	=	92,7		1	**0,092**
2	Exterior wall north	8	Exterior Wall - Ambient	1	x (	21,96	x	6,07	+		-		) -	10,5	=	122,8		1	**0,092**
3	Exterior wall west	8	Exterior Wall - Ambient	1	x (	11,68	x	6,78	+		-		) -	3,8	=	75,3		1	**0,092**
4	Roof - south	10	Roof/Ceiling - Ambient	1	x (	21,60	x	5,79	+		-		) -	0,0	=	125,1		2	**0,092**
5	Basement floor	11	Floor Slab	1	x (		x		+	247,77	-		) -	0,0	=	247,8		3	**0,089**
6	Exterior wall east	8	Exterior Wall - Ambient	1	x (	14,95	x	7,33	+		-		) -	17,2	=	92,4		1	**0,092**
7	Roof - north	10	Roof/Ceiling - Ambient	1	x (	21,60	x	7,16	+		-		) -	0,0	=	154,7		2	**0,092**
8	Exterior wall - ground/con	9	Exterior Wall - Ground	1	x (	40,40	x	1,45	+		-		) -	0,0	=	58,6		4	**0,103**
9	Exterior wall - ground/woo	9	Exterior Wall - Ground	1	x (	29,69	x	0,65	+		-		) -	0,0	=	19,3		5	**0,093**
10					x (		x		+		-		) -	0,0	=			0	
11					x (		x		+		-		) -	0,0	=			0	
12					x (		x		+		-		) -	0,0	=			0	
13					x (		x		+		-		) -	0,0	=			0	
14					x (		x		+		-		) -	0,0	=			0	
15					x (		x		+		-		) -	0,0	=			0	
16					x (		x		+		-		) -	0,0	=			0	
17					x (		x		+		-		) -	0,0	=			0	
18					x (		x		+		-		) -	0,0	=			0	
19					x (		x		+		-		) -	0,0	=			0	
20					x (		x		+		-		) -	0,0	=			0	
21					x (		x		+		-		) -	0,0	=			0	
22					x (		x		+		-		) -	0,0	=			0	
23					x (		x		+		-		) -	0,0	=			0	
24					x (		x		+		-		) -	0,0	=			0	
25					x (		x		+		-		) -	0,0	=			0	
26					x (		x		+		-		) -	0,0	=			0	
27					x (		x		+		-		) -	0,0	=			0	
28					x (		x		+		-		) -	0,0	=			0	
29					x (		x		+		-		) -	0,0	=			0	
30					x (		x		+		-		) -	0,0	=			0	
31					x (		x		+		-		) -	0,0	=			0	
32					x (		x		+		-		) -	0,0	=			0	
33					x (		x		+		-		) -	0,0	=			0	
34					x (		x		+		-		) -	0,0	=			0	
35					x (		x		+		-		) -	0,0	=			0	
36					x (		x		+		-		) -	0,0	=			0	
37					x (		x		+		-		) -	0,0	=			0	
38					x (		x		+		-		) -	0,0	=			0	
39					x (		x		+		-		) -	0,0	=			0	
40					x (		x		+		-		) -	0,0	=			0	
41					x (		x		+		-		) -	0,0	=			0	
42					x (		x		+		-		) -	0,0	=			0	
43					x (		x		+		-		) -	0,0	=			0	
44					x (		x		+		-		) -	0,0	=			0	
45					x (		x		+		-		) -	0,0	=			0	
46					x (		x		+		-		) -	0,0	=			0	
47					x (		x		+		-		) -	0,0	=			0	
48					x (		x		+		-		) -	0,0	=			0	
49					x (		x		+		-		) -	0,0	=			0	
50					x (		x		+		-		) -	0,0	=			0	
FLend																			

Passive House Planning

AREAS DETERMINATION

Building: LIPA Environmental centre   Heat Demand 15 kWh/(m²a)

Group Nr.	Area Group	Temp Zone	Area	Unit	Comments	Building Element Overview	Average U-Value [W/(m²K)]
Summary							
1	**Treated Floor Area**		**486,00**	m²	*Living area or useful area within the thermal envelope*		
2	**North Windows**	**A**	**10,50**	m²	Results are from the Windows worksheet.	**North Windows**	**0,697**
3	**East Windows**	**A**	**17,19**	m²		**East Windows**	**0,662**
4	**South Windows**	**A**	**33,91**	m²		**South Windows**	**0,691**
5	**West Windows**	**A**	**3,84**	m²		**West Windows**	**0,730**
6	**Horizontal Windows**	**A**	**0,00**	m²		**Horizontal Windows**	
7	**Exterior Door**	**A**	**0,00**	m²	*Please subtract area of door from respective building element*	**Exterior Door**	
8	**Exterior Wall - Ambient**	**A**	**383,25**	m²	*Window areas are subtracted from the individual areas specified in the "Windows" worksheet.*	**Exterior Wall - Ambient**	**0,092**
9	**Exterior Wall - Ground**	**B**	**77,88**	m²	*Temperature Zone "A" is ambient air.*	**Exterior Wall - Ground**	**0,100**
10	**Roof/Ceiling - Ambient**	**A**	**279,72**	m²	*Temperature zone "B" is the ground.*	**Roof/Ceiling - Ambient**	**0,092**
11	**Floor Slab**	**B**	**247,77**	m²		**Floor Slab**	**0,089**
12			**0,00**	m²	*Temperature zones "A", "B","P" and "X" may be used. NOT "I"*		
13			**0,00**	m²	*Temperature zones "A", "B","P" and "X" may be used. NOT "I"* Factor for X		
14		**X**	**0,00**	m²	*Temperature zone "X": Please provide user-defined reduction factor (0 < f_t < 1):* 75%		
						Thermal Bridge Overview	**Ψ [W/(mK)]**
15	**Thermal Bridges Ambient**	**A**	**0,00**	m	*Units in m*	**Thermal Bridges Ambient**	
16	**Perimeter Thermal Bridges**	**P**	**0,00**	m	*Units in m; temperature zone "P" is perimeter (see Ground worksheet).*	**Perimeter Thermal Bridges**	
17	**Thermal Bridges Floor Slab**	**B**	**0,00**	m	*Units in m*	**Thermal Bridges Floor Slab**	
18	**Partition Wall to Neighbour**	**I**	**0,00**	m²	*No heat losses, only considered for the heat load calculation.*	**Partition Wall to Neighbour**	
Total Thermal Envelope			**1054,06**	**m²**		**Average Therm. Envelope**	**0,129**

Thermal Bridge Inputs

Nr. of Thermal Bridge	Thermal Bridge Description	Group Nr.	Assigned to Group	Quantity	x (	User Determined Length [m]	-	Subtraction User-Determined Length [m]	) =	Length ℓ [m]	Input of Thermal Bridge Heat Loss Coefficient W/(mK)	Ψ W/(mK)
1	Ext. wall-basement	15	Thermal Bridges Ambient	1	x (	0,00	-		) =	0,00	Ext. wall-basement	-0,039
2	Int. wall-basement	17	Thermal Bridges Floor Slab	1	x (	0,00	-		) =	0,00	Int. wall-basement	0,061
3	Partition walls	15	Thermal Bridges Ambient	1	x (	0,00	-		) =	0,00	Partition walls	0,000
4	Interior ceilings	15	Thermal Bridges Ambient	1	x (	0,00	-		) =	0,00	Interior ceilings	0,002
5	Partition wall-roof	15	Thermal Bridges Ambient	1	x (	0,00	-		) =	0,00	Partition wall-roof	0,005
6	Ext. wall-roof	15	Thermal Bridges Ambient	1	x (	0,00	-		) =	0,00	Ext. wall-roof	-0,061
7	Ext. wall edge	15	Thermal Bridges Ambient	1	x (	0,00	-		) =	0,00	Ext. wall edge	-0,062
8					x (		-		) =			
9					x (		-		) =			
10					x (		-		) =			
11					x (		-		) =			
12					x (		-		) =			
13					x (		-		) =			
14					x (		-		) =			
15					x (		-		) =			
16					x (		-		) =			
17					x (		-		) =			
18					x (		-		) =			
19					x (		-		) =			
20					x (		-		) =			
21					x (		-		) =			
22					x (		-		) =			
23					x (		-		) =			
24					x (		-		) =			
25					x (		-		) =			
26					x (		-		) =			
27					x (		-		) =			
28					x (		-		) =			
29					x (		-		) =			
30					x (		-		) =			
31					x (		-		) =			
32					x (		-		) =			
33					x (		-		) =			
34					x (		-		) =			
35					x (		-		) =			
36					x (		-		) =			
37					x (		-		) =			
38					x (		-		) =			
39					x (		-		) =			
40					x (		-		) =			
41					x (		-		) =			
42					x (		-		) =			
43					x (		-		) =			
44					x (		-		) =			
45					x (		-		) =			
46					x (		-		) =			
47					x (		-		) =			
48					x (		-		) =			
49					x (		-		) =			
50					x (		-		) =			
TBend												

Passive House Planning

REDUCTION FACTOR SOLAR RADIATION, WINDOW U-VALUE

Building: LIPA Environmental centre

Annual Heat Demand: 15 kWh/(m²a)

Heating Degree Hours: 103,6

Climate: N - Oslo

Window Area Orientation	Radiation (Cardinal	Shading	Dirt	Perpendicular Incident	Glazing Fraction	g-Value	for Solar	Window Area	Window U-Value	Glazing Area	Global	Transmission Losses	Solar
maximum:	kWh/(m²a)	0,75	0,95	0,85				m²	W/(m²K)	m²	kWh/(m²a)	kWh/a	kWh/a
North	63	0,93	0,95	0,85	0,665	0,50	0,50	10,50	0,70	7,0	65	758	171
East	180	0,93	0,95	0,85	0,768	0,50	0,58	17,19	0,66	13,2	132	1178	654
South	432	0,95	0,95	0,85	0,681	0,50	0,52	33,91	0,69	23,1	418	2428	3714
West	182	0,84	0,95	0,85	0,554	0,50	0,37	3,84	0,73	2,1	242	290	174
Horizontal	233	0,75	0,95	0,85	0,000	0,00	0,00	0,00	0,00	0,0	233	0	0
		Total or Average Value for All Windows.				0,50	0,52	65,44	0,69	45,4		4654	4712

Quantity	Description	Deviation from North	Angle of Inclination from the Horizontal	Orientation	Window Rough Openings: Width	Window Rough Openings: Height	Installed: in Area in the Areas worksheet	Nr.	Glazing: Select glazing from the WinType worksheet	Nr.	Frame: Select window from the WinType worksheet	Nr.	g-Value: Perpendicular Radiation
		Degrees	Degrees		m	m	Select:		Select:		Select:		-
6	S Ground Fl.	163	90	South	1,200	1,200		1		2		1	0,50
7	S First Fl.	163	90	South	1,900	1,900		1		2		1	0,50
								0		0		0	
1	N Ground Fl.	343	90	North	1,400	0,900		2		2		1	0,50
1	N Ground Fl.	343	90	North	2,000	2,500		2		2		1	0,50
1	N Ground Fl.	343	90	North	2,600	0,800		2		2		1	0,50
1	N Ground Fl.	343	90	North	1,200	1,800		2		2		1	0,50
								0		0		0	
1	East	73	90	East	1,100	0,800		6		2		1	0,50
1	East	73	90	East	1,500	1,100		6		2		1	0,50
1	East	73	90	East	1,500	2,000		6		2		1	0,50
1	East	73	90	East	3,700	3,150		6		2		1	0,50
								0		0		0	
2	West	253	90	West	1,200	1,200		3		2		1	0,50
1	West	253	90	West	0,800	1,200		3		2		1	0,50
								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		0	
								0		0		0	
								0		0		0	
								0		0		0	
								0		0		0	
								0		0		0	
								0		0		0	

Description	U-Value: Glazing	U-Value: Frames	Window Frame Dimensions: Width - Left	Width - Right	Width - Below	Width - Above	Installation: Left 1/0	Right 1/0	Sill 1/0	Head 1/0	Ψ-Value: Ψ_{Spacer}	$\Psi_{Installation}$	Results: Window Area	Glazing Area	U-Value Window	Glazed Fraction per Window
	W/(m²K)	W/(m²K)	m	m	m	m					W/(mK)	W/(mK)	m²	m²	W/(m²K)	%
S Ground Fl.	0,58	0,59	0,14	0,14	0,18	0,14	1	1	1	1	0,049	0,005	8,6	4,97	0,72	0,57
S First Fl.	0,58	0,59	0,14	0,14	0,18	0,14	1	1	1	1	0,049	0,005	25,3	18,14	0,68	0,72
N Ground Fl.	0,58	0,59	0,14	0,14	0,18	0,14	1	1	1	1	0,049	0,005	1,3	0,67	0,74	0,53
N Ground Fl.	0,58	0,59	0,14	0,14	0,18	0,14	1	1	1	1	0,049	0,005	5,0	3,79	0,67	0,76
N Ground Fl.	0,58	0,59	0,14	0,14	0,18	0,14	1	1	1	1	0,049	0,005	2,1	1,14	0,73	0,55
N Ground Fl.	0,58	0,59	0,14	0,14	0,18	0,14	1	1	1	1	0,049	0,005	2,2	1,39	0,71	0,64
East	0,58	0,59	0,14	0,14	0,18	0,14	1	1	1	1	0,049	0,005	0,9	0,41	0,75	0,46
East	0,58	0,59	0,14	0,14	0,18	0,14	1	1	1	1	0,049	0,005	1,7	0,97	0,72	0,59
East	0,58	0,59	0,14	0,14	0,18	0,14	1	1	1	1	0,049	0,005	3,0	2,08	0,69	0,69
East	0,58	0,59	0,14	0,14	0,18	0,14	1	1	1	1	0,049	0,005	11,7	9,74	0,64	0,84
West	0,58	0,59	0,14	0,14	0,18	0,14	1	1	1	1	0,049	0,005	2,9	1,66	0,72	0,57
West	0,58	0,59	0,14	0,14	0,18	0,14	1	1	1	1	0,049	0,005	1,0	0,47	0,75	0,49

Passive House Planning

HEAT LOSSES VIA THE GROUND

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			
Av. Indoor Temp. Winter	T_i	20,0	°C
Av. Indoor Temp. Summer	T_i	25,0	°C
Average Ground Surface Temperature	$T_{g,ave}$	6,1	°C
Amplitude of $T_{g,ave}$	$T_{g,^}$	10,6	°C
Length of the Heating Period	n	6,7	months
Heating Degree Hours - Exterior	G_t	103,6	kKh/a

Building Data							
Floor Slab Area	A	292,0	m²	Floor Slab U-Value	U_f	0,089	W/(m²K)
Floor Slab Perimeter	P	70,6	m	Thermal Bridges at Floor Slab	Ψ_B*l	0,00	W/K
Charact. Dimension of Floor Slab	B'	8,27	m	Floor Slab U-Value incl. TB	U_f'	0,089	W/(m²K)
				Eq. Thickness Floor	d_t	22,4	m

Floor Slab Type (select only one) **Please choose one option only.**

x	Heated Basement or Underground Floor Slab		Unheated basement
	Slab on Grade		Suspended Floor

For Basement or Underground Floor Slab							
Basement Depth	z	1,00	m	U-Value Belowground Wall	U_{wB}	0,098	W/(m²K)
Additionally for Unheated Basements				Height Aboveground Wall	h		m
Air Change Unheated Basement	n		h⁻¹	U-Value Aboveground Wall	U_W		W/(m²K)
Basement Volume	V		m³	U-Value Basement Floor Slab	U_{fB}		W/(m²K)

For Perimeter Insulation for Slab on Grade			
Perimeter Insulation Width/Depth	D		m
Perimeter Insulation Thickness	d_n		m
Conductivity Perimeter Insulation	λ_n		W/(mK)
Location of the Perimeter Insulation	horizontal		
(check only one field)	vertical	x	

For Suspended Floor			
U-Value Crawl Space	U_{Crawl}		W/(m²K)
Height of Crawl Space Wall	h		m
U-Value Crawl Space Wall	U_W		W/(m²K)
Area of Ventilation Openings	εP		m²
Wind Velocity at 10 m Height	v		m/s
Wind Shield factor	f_W		-

Additional Thermal Bridge Heat Losses at Perimeter							
Phase Shift	β		months	Steady-State Fraction	$\Psi_{P,stat}$*l	0,000	W/K
				Harmonic Fraction	$\Psi_{P,harm}$*l	0,000	W/K

Groundwater Correction							
Depth of the Groundwater Table	z_W		m	Transm. Belowground El. (w/o Ground)	L_{reg}	32,98	W/K
Groundwater Flow Rate	q_W		m/d	Relative Insulation Standard	d_t/B'	2,66	-
				Relative Groundwater Depth	z_W/B'	0,00	-
Groundwater Correction Factor	G_W	-		Relative Groundwater Velocity	l/B'		-

Basement or Underground Floor Slab							
Eq. Thickness Floor Slab	d_t	22,4	m	Phase Shift	β	1,44	months
U-Value Floor Slab	U_{bf}	0,07	W/(m²K)	Exterior Periodic Transmittance	L_{pe}	9,12	W/K
Eq. Thickness Basement Wall	d_w	20,41	m				
U-Value Wall	U_{bw}	0,09	W/(m²K)				
Steady-State Transmittance	L_s	28,23	W/K				

Unheated Basement							
Steady-State Transmittance	L_S		W/K	Phase Shift	β		months
				Exterior Periodic Transmittance	L_{pe}		W/K

Slab on Grade							
Heat Transfer Coefficient	U_0		W/(m²K)	Phase Shift	β		months
Eq. Ins. Thickness Perimeter Ins.	d'		m	Exterior Periodic Transmittance	L_{pe}		W/K
Perimeter Insulation Correction	ΔΨ		W/(mK)				
Steady-State Transmittance	L_S		W/K				

Suspended Floor Above a Ventilated Crawl Space (at max. 0.5 m Below Ground)							
Eq. Ins. Thickness Crawl Space	d_g		m	Phase Shift	β		months
U-Value Crawl Space Floor Slab	U_g		W/(m²K)	Exterior Periodic Transmittance	L_{pe}		W/K
U-Value Crawl Space Wall & Vent.	U_X		W/(m²K)				
Steady-State Transmittance	L_S		W/K				

Interim Results							
Phase Shift	β	1,44	months	Steady-State Heat Flow	Φ_{stat}	391,0	W
Steady-State Transmittance	L_S	28,23	W/K	Periodic Heat Flow	Φ_{harm}	39,2	W
Exterior Periodic Transmittance	L_{pe}	9,12	W/K	Heat Losses During Heating Period	Q_{tot}	2112	kWh

Ground Reduction Factor for "Annual Heat Demand" Sheet **0,618**

Monthly Average Ground Temperatures for Monthly Method

Month	1	2	3	4	5	6	7	8	9	10	11	12	Average Valı
Winter	6,0	5,3	5,3	6,1	7,5	9,0	10,3	11,0	11,0	10,2	8,8	7,3	8,1
Summer	6,7	6,0	6,1	6,9	8,2	9,7	11,0	11,7	11,7	10,9	9,5	8,0	8,9

Design Ground Temperature for Heat Load Sheet **5,3** **for Cooling Load Sheet** **11,7**

Passive House Planning

U - L I S T

Compilation of the building elements calculated in the U-Values worksheet and other construction types from databases.

	Type		
Assembly No.	Assembly Description	Total Thickness	U-Value
		m	W/(m²K)
1	Exterior wall	0,477	0,09
2	Roof	0,418	0,09
3	Ground Floor	0,552	0,09
4	Exterior wall - ground/concrete	0,630	0,10
5	Exterior wall - ground/wood	0,477	0,09
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21	Wood24-old	0,275	1,440
22	Solid Brick 38-old	0,415	1,640
23	Framework18-old	0,210	1,800
24	VerticalCoringBrick30-old	0,335	1,230
25	PrecastConcrete-old	0,275	1,300
26	WoodenJoistCeiling-old	0,284	0,990
27	BasementFloor-old	0,242	1,230
28			
29	AW-ALS032-mas: alseco, exterior insulation compound system on masonry	0,500	0,100
30	AW-ALS034/035-mas: alseco, exterior insulation compound system on masonry	0,500	0,110
31	AW-ALS040/041-mas: alseco, exterior insulation compound system on masonry	0,500	0,130
32	AW-ALG032-mas: Alligator, exterior insulation compound system on masonry	0,500	0,100
33	AW-ALG034/035-mas: Alligator, exterior insulation compound system on masonry	0,500	0,110
34	AW-ALG040/041-mas: Alligator, exterior insulation compound system on masonry	0,500	0,130
35	AW-CAP032-mas: Caparol, exterior insulation compound system on masonry	0,500	0,100
36	AW-CAP034/035-mas: Caparol, exterior insulation compound system on masonry	0,500	0,110
37	AW-CAP040/041-mas: Caparol, exterior insulation compound system on masonry	0,500	0,130
38	AW-FGH035-lei: Fingerhaus, wooden beam load-bearing wall with ETICS	0,415	0,100
39	AW-FIN040-lei: Finnforest Merk, FJI-beam	0,404	0,120
40	AW-GPT031-mas: Gisoplan-Therm 375/225, ICF from expanded clay	0,400	0,120
41	AW-GRE050-mas: Greisel, exterior insulation compound system on porous concre	0,515	0,119
42	AW-HEB045-mas: Hebel, exterior insulation compound system on porous concret	0,470	0,140
43	AW-HVH035-mas: Heinz von Heiden, exterior insulation compound system on Ytor	0,497	0,101
44	AW-HVH040-lei: Heinz von Heiden, lightweight wall with exterior insulation c	0,453	0,094
45	AW-ISR035-dws: isorast, insulating concrete form Dickwandstein	0,400	0,140
46	AW-ISR035-sdw: isorast, insulating concrete form Superdickwandstein	0,463	0,110
47	AW-MAR035-mas: Marmorit, ETICS from limestone and PS	0,500	0,110
48	AW-MAR040-mas: Marmorit, ETICS from limestone and MW	0,500	0,130
49	AW-NUS035-mas: Naumann&Stahr, wooden lightweight elements with DokAW-beams	0,423	0,120
50	AW-STO035-mas: Sto, ETICS from limestone and PS 035	0,495	0,110
51	AW-STO040-mas: Sto, ETICS from limestone and PS 040	0,495	0,130
52	AW-WOC250-mas: Wochner, ETICS from porous concrete and PS, 250	0,460	0,130
53	AW-WOC300-mas: Wochner, ETICS from porous concrete and PS, 250	0,510	0,110
54	DA-ALS045-lei: alseco, lightweight roof	0,395	0,140
55	DA-ALS040-Fla: alseco, Flachdach	0,515	0,130
56	DA-ALG045-lei: Alligator, lightweight roof	0,395	0,140
57	DA-ALG040-Fla: Alligator, flat roof	0,515	0,130
58	DA-CAP045-lei: Caparol, lightweight roof	0,395	0,140
59	DA-CAP040-Fla: Caparol, flat roof	0,515	0,130
60	DA-FGH035-lei: Fingerhaus, lightweight roof	0,333	0,130
61	DA-FIN040-lei: Finnforest Merk, lightweight roof	0,344	0,141
62	DA-GIS035-lei: Gisoton, lightweight roof	0,343	0,130
63	DA-GIS035-mas: Gisoton, massive roof	0,510	0,110
64	DA-GRE035-mas: Greisel, flat roof	0,610	0,086
65	DA-GRE035-lei: Greisel, lightweight roof	0,438	0,107
66	DA-HEB045-mas: Hebel, massive roof	0,510	0,130
67	DA-HVH030/040-mas: Heinz von Heiden, lightweight roof	0,393	0,103

Passive House Planning
U-VALUES OF BUILDING ELEMENTS

Wedge Shaped Building Element Layers and Still Air Spaces -> Secondary Calculation to the Right

Building: LIPA Environmental centre

Assembly No.	Building Assembly Description
1	Exterior wall

Heat Transfer Resistance [m²K/W] interior R_{si}: 0,13 exterior R_{se}: 0,13

	Area Section 1	λ [W/(mK)]	Area Section 2 (optional)	λ [W/(mK)]	Area Section 3 (optional)	λ [W/(mK)]	Total Width Thickness [mm]
1.	Rockwool	0,038					200
2.	OSB	0,130					18
3.	Rockwool	0,038					123
4.	Massive wood	0,130					60
5.	OSB	0,130					18
6.	Rockwool	0,038					48
7.	Interior cladding	0,100					10
8.							

Percentage of Sec. 2 | Percentage of Sec. 3 | Total 47,7 cm 1/R

U-Value: 0,092 W/(m²K)

Assembly No.	Building Assembly Description
2	Roof

Heat Transfer Resistance [m²K/W] interior R_{si}: 0,10 exterior R_{se}: 0,10

	Area Section 1	λ [W/(mK)]	Area Section 2 (optional)	λ [W/(mK)]	Area Section 3 (optional)	λ [W/(mK)]	Total Width Thickness [mm]
1.	Rockwool	0,038					400
2.	OSB	0,130					18
3.							
4.							
5.							
6.							
7.							
8.							

Percentage of Sec. 2: 2,0% | Percentage of Sec. 3 | Total 41,8 cm 1/R

U-Value: 0,092 W/(m²K)

Assembly No.	Building Assembly Description
3	Ground Floor

Heat Transfer Resistance [m²K/W] interior R_{si}: 0,17 exterior Rse: 0,00

	Area Section 1	λ [W/(mK)]	Area Section 2 (optional)	λ [W/(mK)]	Area Section 3 (optional)	λ [W/(mK)]	Total Width Thickness [mm]
1.	Parquet	0,130					22
2.	Rockwool	0,038					50
3.	Concrete	2,100					100
4.	Foam glass	0,040					380
5.							
6.							
7.							
8.							

Percentage of Sec. 2 | Percentage of Sec. 3 | Total 55,2 cm 1/R

U-Value: 0,089 W/(m²K)

Passive House Planning
U-VALUES OF BUILDING ELEMENTS

Wedge Shaped Building Element Layers and
Still Air Spaces -> Secondary Calculation to the Right

Building: LIPA Environmental centre

Assembly No.	Building Assembly Description
4	Exterior wall - ground/concrete

Heat Transfer Resistance [m²K/W] interior R_{si}: 0,13
exterior R_{se}: 0,00

	Area Section 1	λ [W/(mK)]	Area Section 2 (optional)	λ [W/(mK)]	Area Section 3 (optional)	λ [W/(mK)]	Total Width Thickness [mm]
1.	Foam glass	0,040					380
2.	Concrete	2,100					250
3.							
4.							
5.							
6.							
7.							
8.							

Percentage of Sec. 2 | Percentage of Sec. 3 | Total 63,0 cm | 1/R

U-Value: 0,103 W/(m²K)

Assembly No.	Building Assembly Description
5	Exterior wall - ground/wood

Heat Transfer Resistance [m²K/W] interior R_{si}: 0,13
exterior R_{se}: 0,00

	Area Section 1	λ [W/(mK)]	Area Section 2 (optional)	λ [W/(mK)]	Area Section 3 (optional)	λ [W/(mK)]	Total Width Thickness [mm]
1.	Rockwool	0,038					200
2.	OSB	0,130					18
3.	Rockwool	0,038					123
4.	Massive wood	0,130					60
5.	OSB	0,130					18
6.	Rockwool	0,038					48
7.	Interior cladding	0,100					10
8.							

Percentage of Sec. 2 | Percentage of Sec. 3 | Total 47,7 cm | 1/R

U-Value: 0,093 W/(m²K)

Assembly No.	Building Assembly Description
6	

Heat Transfer Resistance [m²K/W] interior R_{si}:
exterior R_{se}:

	Area Section 1	λ [W/(mK)]	Area Section 2 (optional)	λ [W/(mK)]	Area Section 3 (optional)	λ [W/(mK)]	Total Width Thickness [mm]
1.							
2.							
3.							
4.							
5.							
6.							
7.							
8.							

Percentage of Sec. 2 | Percentage of Sec. 3 | Total cm | 1/R

U-Value: W/(m²K)

Passive House Planning

G L A Z I N G   A C C O R D I N G   T O   C E R T I F I C A T I O N

for frame types, go to row: 71

	Type		
Assembly No.	Glazing	g-Value	U_g-Value
			W/(m²K)
1	Triple-low-e Kr08	0,500	0,700
2	Triple-low-e Kr12	0,500	0,580
3	28 Low-E 0.51 N 52 - GUARDIAN Flachglas	0,520	0,510
4	37 iPlus 3S - INTERPANE	0,520	0,600
5	Double windows	0,400	0,500
6			
7			
8			
9			
10			
11			

Passive House Planning
FRAME TYPE ACCORDING TO CERTIFICATION

for glazings, go to row: 2

	Type	U_f-Value	Frame Dimensions				Thermal Bridge	Thermal Bridge
Assembly No.	Frame	Frame	Width - Left	Width - Right	Width - Below	Width - Above	Ψ_{Spacer}	$\Psi_{Installation}$
		W/(m²K)	m	m	m	m	W/(mK)	W/(mK)
1	standard PU on wood	0,59	0,135	0,135	0,175	0,135	0,049	0,005
2	junction PU on wood	0,59	0,070	0,125	0,125	0,125	0,049	0,005
3	wide PU on wood	0,59	0,150	0,150	0,175	0,150	0,049	0,005
4								
5								
6								
7								
8								
9								
10								
11								

Passive House Planning

C A L C U L A T I N G   S H A D I N G   F A C T O R S

Climate: N - Oslo

Building: LIPA Environmental centre

Latitude: 59,93 °

Orien-tation	Glazing Area	Reduction Factor
	m²	r_S
North	6,98	93%
East	13,20	93%
South	23,11	95%
West	2,13	84%
Horizontal	0,00	100%

Quantity	Description	Deviation from North	Angle of Inclination from the Horizontal	Orientation	Glazing Width	Glazing Height	Glazing Area	Height of the Shading Object	Horizontal Distance	Window Reveal Depth	Distance from Glazing Edge to Reveal	Overhang Depth	Distance from Upper Glazing Edge to Overhang	Additional Shading Reduction Factor	Horizontal Shading Reduction Factor	Reveal Shading Reduction Factor	Overhang Shading Reduction Factor	Total Shading Reduction Factor
		Degrees	Degrees		m	m		m	m	m	m	m	m	%	%	%	%	%
					w_G	h_G	A_G	h_{Hori}	d_{Hori}	o_{Reveal}	d_{Reveal}	o_{over}	d_{over}	r_{other}	r_H	r_R	r_O	r_S
6	S Ground Fl.	163	90	South	0,93	0,89	5,0			0,20	0,100				100%	93%	100%	93%
7	S First Fl.	163	90	South	1,63	1,59	18,1			0,20	0,100				100%	96%	100%	96%
										0,20	0,100					51%		
1	N Ground Fl.	343	90	North	1,13	0,59	0,7			0,20	0,100				100%	91%	100%	91%
1	N Ground Fl.	343	90	North	1,73	2,19	3,8			0,20	0,100				100%	94%	100%	94%
1	N Ground Fl.	343	90	North	2,33	0,49	1,1			0,20	0,100				100%	95%	100%	95%
1	N Ground Fl.	343	90	North	0,93	1,49	1,4			0,20	0,100				100%	90%	100%	90%
1	East	73	90	East	0,83	0,49	0,4			0,20	0,100				100%	84%	100%	84%
1	East	73	90	East	1,23	0,79	1,0			0,20	0,100				100%	88%	100%	88%
1	East	73	90	East	1,23	1,69	2,1			0,20	0,100				100%	88%	100%	88%
1	East	73	90	East	3,43	2,84	9,7			0,20	0,100				100%	95%	100%	95%
2	West	253	90	West	0,93	0,89	1,7			0,20	0,100				100%	85%	100%	85%
1	West	253	90	West	0,53	0,89	0,5			0,20	0,100				100%	78%	100%	78%

Passive House Planning

VENTILATION DATA

Building: LIPA Environmental centre

Treated Floor Area A_{TFA}	m²	486	*(Areas worksheet)*
Room Height h	m	2,5	*(Annual Heat Demand worksheet)*
Room Ventilation Volume (A_{TFA}*h) = V_V	m³	1215	*(Annual Heat Demand worksheet)*

Ventilation System Design - Standard Operation

Occupancy	m²/P	35				
Number of Occupants	P	13,9				
Supply Air per Person	m³/(P*h)	30				
Supply Air Requirement	m³/h	417				
Extract Air Rooms		Kitchen	Bathroom	Shower	WC	
Quantity		1	1	2	4	
Extract Air Requirement per Room	m³/h	60	40	20	20	
Total Extract Air Requirement	m³/h	220				

Design Air Flow Rate (Maximum) m³/h **474**

Average Air Change Rate Calculation

Type of Operation	Daily Operation Duration h/d	Factors Referenced to Maximum	Air Flow Rate m³/h	Air Change Rate 1/h
Maximum		1,00	474	0,39
Standard	24,0	0,77	365	0,30
Basic		0,54	255	0,21
Minimum		0,40	190	0,16
x Residential Building	Average value	0,77	Average Air Flow Rate (m³/h) 365	Average Air Change Rate (1/h) 0,30

Infiltration Air Change Rate according to EN 13790

Wind Protection Coefficients According to EN 13790		
Coefficient e for Screening Class	Several Sides Exposed	One Side Exposed
No Screening	0,10	0,03
Moderate Screening	0,07	0,02
High Screening	0,04	0,01
Coefficient f	15	20

			for Annual Demand:	for Heat Load:				
Wind Protection Coefficient, e			0,10	0,25				
Wind Protection Coefficient, f			15	15	Net Air Volume for Press. Test V_{n50}		Air Permeability q_{50}	
Air Change Rate at Press. Test	n_{50}	1/h	0,50	0,50	1790	m³	0,85	m³/(h

Type of Ventilation System

x Balanced PH Ventilation	*Please Check*		for Annual Demand:	for Heat Load:
Pure Extract Air				
Excess Extract Air		1/h	0,00	0,00
Infiltration Air Change Rate	$n_{V,Res}$	1/h	0,074	0,184

Effective Heat Recovery Efficiency of the Ventilation System with Heat Recovery

x Central unit within the thermal envelope.

Central unit outside of the thermal envelope.

Efficiency of Heat Recovery	η_{HR}		0,90		
Transmittance Ambient Air Duct	Ψ	W/(mK)	0,000	Calculation see Secondary Calculation	
Length Ambient Air Duct		m			
Transmittance Exhaust Air Duct	Ψ	W/(mK)	0,000	Calculation see Secondary Calculation	
Length Exhaust Air Duct		m		Room Temperature (°C)	20
Temperature of Mechanical Services Room		°C		Av. Ambient Temp. Heating P. (°C)	-1,1
(Enter only if the central unit is outside of the thermal envelope.)				Av. Ground Temp (°C)	6,1

Effective Heat Recovery Efficiency $\eta_{HR,eff}$ **90,0%**

Effective Heat Recovery Efficiency Subsoil Heat Exchanger

SHX Efficiency	η^*_{SHX}	93%
Heat Recovery Efficiency SHX	η_{SHX}	32%

Passive House Planning

SPECIFIC ANNUAL HEAT DEMAND

Climate:	N - Oslo	Interior Temperature:	20,0 °C
Building:	LIPA Environmental centre	Building Type/Use:	Dwelling
Location:	Linesoya	Treated Floor Area A_{TFA}:	486,0 m²

	Building Element	Temperature Zone	Area m²		U-Value W/(m²K)		Temp. Factor f_t		G_t kKh/a		kWh/a	per m² Treated Floor Area
1.	Exterior Wall - Ambient	A	383,3	*	0,092	*	1,00	*	103,6	=	3654	
2.	Exterior Wall - Ground	B	77,9	*	0,100	*	0,62	*	103,6	=	500	
3.	Roof/Ceiling - Ambient	A	279,7	*	0,092	*	1,00	*	103,6	=	2666	
4.	Floor Slab	B	247,8	*	0,089	*	0,62	*	103,6	=	1416	
5.		A		*		*	1,00	*		=		
6.		A		*		*	1,00	*		=		
7.		X		*		*	0,75	*		=		
8.	Windows	A	65,4	*	0,687	*	1,00	*	103,6	=	4654	
9.	Exterior Door	A		*		*	1,00	*		=		
10.	Exterior TB (length/m)	A		*		*	1,00	*		=		
11.	Perimeter TB (length/m)	P		*		*	0,62	*		=		
12.	Ground TB (length/m)	B		*		*	0,62	*		=		
		Total of All Building Envelope Areas	1054,1									kWh/(m²a)
	Transmission Heat Losses Q_T									Total	12891	26,5

			A_{TFA} m²		Clear Room Height m		m³
Ventilation System:	Effective Air Volume, V_V		486,0	*	2,50	=	1215,0
Effective Heat Recovery Efficiency of Heat Recovery	η_{eff}	90%					
Efficiency of Subsoil Heat Exchanger	η_{SHX}	32%					

	$n_{V,system}$ 1/h		Φ_{HR}		$n_{V,Res}$ 1/h		1/h
Energetically Effective Air Exchange n_v	0,300	(1 -	0,93	) +	0,074	=	0,094

	V_V m³		n_V 1/h		c_{Air} Wh/(m³K)		G_t kKh/a		kWh/a	kWh/(m²a)
Ventilation Heat Losses Q_V	1215	*	0,094	*	0,33	*	103,6	=	3907	8,0

		Q_T kWh/a		Q_V kWh/a		Reduction Factor Night/Weekend Saving		kWh/a	kWh/(m²a)
Total Heat Losses Q_L	(	12891	+	3907	)	1,0	=	16798	34,6

	Orientation of the Area	Reduction Factor See Windows Sheet		g-Value (perp. radiation)		Area m²		Radiation HP kWh/(m²a)		kWh/a	kWh/(m²a)
1.	North	0,50	*	0,50	*	10,50	*	65	=	171	
2.	East	0,58	*	0,50	*	17,19	*	132	=	654	
3.	South	0,52	*	0,50	*	33,91	*	418	=	3714	
4.	West	0,37	*	0,50	*	3,84	*	242	=	174	
5.	Horizontal	0,40	*	0,00	*	0,00	*	233	=	0	
	Available Solar Heat Gains Q_S								Total	4712	9,7

	kh/d		Length Heat. Period d/a		Spec. Power q_I W/m²		A_{TFA} m²		kWh/a	kWh/(m²a)
Internal Heat Gains Q_I	0,024	*	205	*	2,10	*	486,0	=	5010	10,3

			kWh/a	kWh/(m²a)
Free Heat Q_F	$Q_S + Q_I$	=	9722	20,0
Ratio of Free Heat to Losses	Q_F / Q_L	=	0,58	
Utilisation Factor Heat Gains η_G	$(1 - (Q_F/Q_L)^5) / (1 - (Q_F/Q_L)^6)$	=	97%	
Heat Gains Q_G	$\eta_G * Q_F$	=	9446	19,4
Annual Heat Demand Q_H	$Q_L - Q_G$	=	7352	**15**

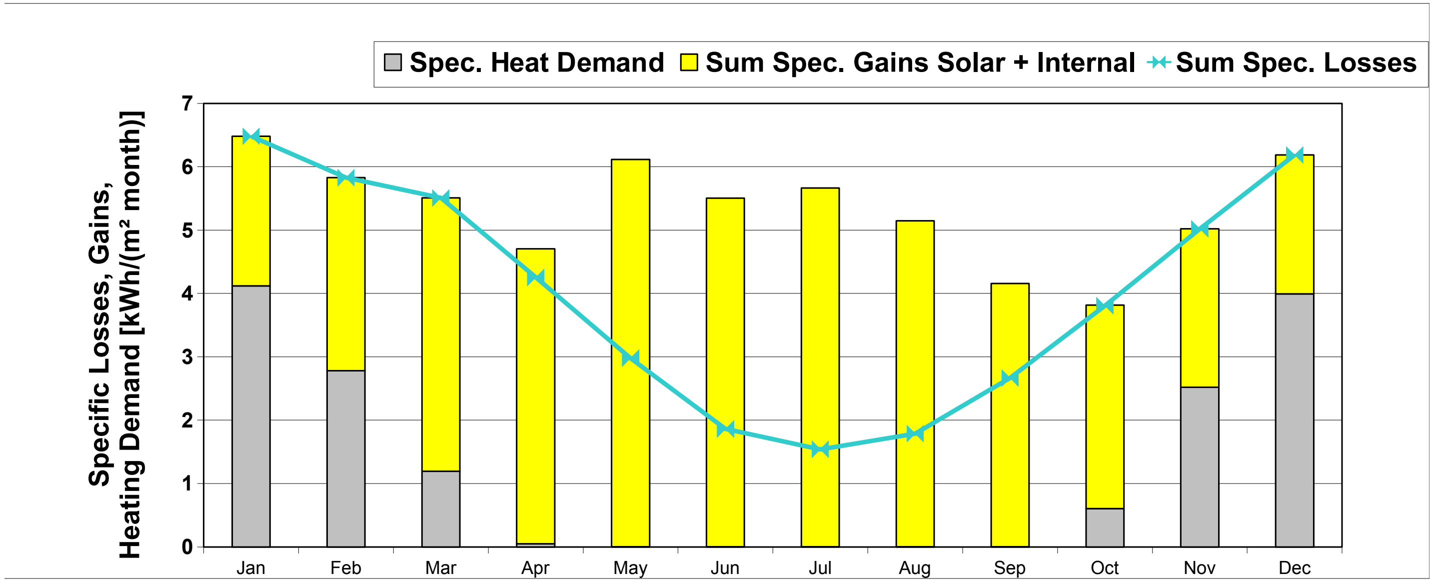
	kWh/(m²a)		(Yes/No)
Limiting Value	15	**Requirement met?**	**Yes**

PASSIVE HOUSE PLANNING

SPECIFIC ANNUAL HEAT DEMAND
MONTHLY METHOD

Climate:	N - Oslo		Interior Temperature:	20 °C
Building:	LIPA Environmental centre		Building Type/Use:	Dwelling
Location:	Linesoya		Treated Floor Area A_{TFA}:	486 m²

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	
Heating Degree Hours - Ex	20,0	17,8	16,3	12,1	7,8	4,2	3,5	4,3	7,5	11,4	15,5	19,2	140	kKh
Heating Degree Hours - G	10,4	9,9	10,9	10,0	9,3	7,9	6,7	6,7	6,5	7,3	8,0	9,4	103	kKh
Losses - Exterior	2722	2426	2228	1656	1065	578	473	593	1027	1549	2109	2618	19045	kWh
Losses - Ground	428	406	449	410	383	326	275	275	268	301	331	388	4241	kWh
Sum Spec. Losses	6,5	5,8	5,5	4,3	3,0	1,9	1,5	1,8	2,7	3,8	5,0	6,2	47,9	kWh/m²
Solar Gains - North	7	19	48	75	139	143	141	103	58	30	10	6	777	kWh
Solar Gains - East	24	78	191	301	500	483	457	353	204	103	35	19	2748	kWh
Solar Gains - South	322	614	931	922	1205	984	1056	1005	846	576	391	256	9108	kWh
Solar Gains - West	11	26	48	61	95	78	83	74	49	27	14	7	573	kWh
Solar Gains - Horiz.	0	0	0	0	0	0	0	0	0	0	0	0	0	kWh
Solar Gains - Opaque	24	58	120	168	273	253	257	206	129	66	31	18	1604	kWh
Internal Heat Gains	759	686	759	735	759	735	759	759	735	759	735	759	8940	kWh
Sum Spec. Gains Solar + I	2,4	3,0	4,3	4,7	6,1	5,5	5,7	5,1	4,2	3,2	2,5	2,2	48,9	kWh/m²
Utilisation Factor	100%	100%	100%	90%	49%	34%	27%	35%	64%	100%	100%	100%	67%	
Annual Heat Demand	2002	1351	579	24	0	0	0	0	0	294	1224	1940	7415	kWh
Spec. Heat Demand	**4,1**	**2,8**	**1,2**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,6**	**2,5**	**4,0**	**15,3**	kWh/m²



Passive House Planning

SPECIFIC SPACE HEATING LOAD

Building:	LIPA Environmental centre	Building Type/Use:	Dwelling
Location:	Linesoya	Treated Floor Area A_{TFA}:	486,0 m² — Interior Temperature: 20 °C
		Climate (HL):	N - Oslo

	Design Temperature		Radiation: North	East	South	West	Horizontal	
Weather Condition 1:	-13,5	°C	5	10	30	15	15	W/m²
Weather Condition 2:	-7,6	°C	5	5	10	5	5	W/m²
Ground Design Temp.	5,3	°C						

	Building Element	Temperature Zone	Area m²		U-Value W/(m²K)		Factor Always 1 (except "X")		TempDiff 1 K		TempDiff 2 K		P_T 1 W		P_T 2 W
1.	Exterior Wall - Ambient	A	383,3	*	0,092	*	1,00	*	33,5	or	27,6	=	1183	or	973
2.	Exterior Wall - Ground	B	77,9	*	0,100	*	1,00	*	14,7	or	14,7	=	115	or	115
3.	Roof/Ceiling - Ambient	A	279,7	*	0,092	*	1,00	*	33,5	or	27,6	=	863	or	710
4.	Floor Slab	B	247,8	*	0,089	*	1,00	*	14,7	or	14,7	=	325	or	325
5.		A		*		*	1,00	*	33,5	or	27,6	=		or	
6.		A		*		*	1,00	*	33,5	or	27,6	=		or	
7.		X		*		*	0,75	*	33,5	or	27,6	=		or	
8.	Windows	A	65,4	*	0,687	*	1,00	*	33,5	or	27,6	=	1507	or	1240
9.	Exterior Door	A		*		*	1,00	*	33,5	or	27,6	=		or	
10.	Exterior TB (length/m)	A		*		*	1,00	*	33,5	or	27,6	=		or	
11.	Perimeter TB (length/m)	P		*		*	1,00	*	14,7	or	14,7	=		or	
12.	Ground TB (length/m)	B		*		*	1,00	*	14,7	or	14,7	=		or	
13.	House/DU Partition Wall	I		*		*	1,00	*	3,0	or	3,0	=		or	

Transmission Heat Losses P_T

Total = 3994 or 3363

Ventilation System:

	A_{TFA} m²		Clear Room Height m		m³
Effective Air Volume, V_V	486,0	*	2,50	=	1215

				η_{SHX} 1		η_{SHX} 2
Efficiency of Heat Recovery of the Heat Exchanger η_{HR}	90%	Heat Recovery Efficiency SHX	93%	Efficiency SHX 55%	or	46%

	$n_{V,Res}$ (Heating Load) 1/h		$n_{V,system}$ 1/h		Φ_{HR}		Φ_{HR}		1/h		1/h
Energetically Effective Air Exchange n_V	0,184	+	0,300	*(1-	0,95	or	0,95	) =	0,198	or	0,200

Ventilation Heating Load P_V

V_L m³		n_L 1/h		n_L 1/h		c_{Air} Wh/(m³K)		TempDiff 1 K		TempDiff 2 K		P_V 1 W		P_V 2 W
1215,0	*	0,198	or	0,200	*	0,33	*	33,5	or	27,6	=	**2660**	or	**2215**

Total Heating Load P_L

		P_L 1 W		P_L 2 W
$P_T + P_V$	=	**6654**	or	**5578**

	Orientation the Area	Area m²		g-Value (perp. radiation)		Reduction Factor (see Windows worksheet)		Radiation 1 W/m²		Radiation 2 W/m²		P_S 1 W		P_S 2 W
1.	North	10,5	*	0,5	*	0,5	*	6	or	5	=	15	or	13
2.	East	17,2	*	0,5	*	0,6	*	7	or	4	=	34	or	22
3.	South	33,9	*	0,5	*	0,5	*	28	or	10	=	251	or	86
4.	West	3,8	*	0,5	*	0,4	*	19	or	6	=	14	or	4
5.	Horizontal	0,0	*	0,0	*	0,4	*	15	or	5	=	0	or	0

Solar Heat Gain, P_S

Total = **314** or **125**

Internal Heat Gains P_I

Spec. Power W/m²		A_{TFA} m²		P_I 1 W		P_I 2 W
1,6	*	486	=	**778**	or	**778**

Heat Gains P_G

		P_G 1 W		P_G 2 W
$P_S + P_I$	=	**1092**	or	**903**
$P_L - P_G$	=	**5562**	or	**4675**

Heating Load P_H = **5562** W

Specific Heating Load P_H / A_{TFA} = **11,4** W/m²

					°C	°C
Input Max. Supply Air Temperature	52	°C				
Max. Supply Air Temperature $\vartheta_{Supply,Max}$	52	°C	Supply Air Temperature Without Heating	$\vartheta_{Supply,Min}$	18,5	18,5

For Comparison: Heating Load Transportable by Supply Air. $P_{Supply\,Air,Max}$ = **4032** W specific: 8,3 W/m²

Supply Air Heating Sufficient? (Yes/No) **No**

Passive House Planning

SUMMER

Climate:	N - Oslo	Interior Temperature:	20 °C
Building:	LIPA Environmental centre	Building Type/Use:	Dwelling
Location:	Linesoya	Treated Floor Area A_{TFA}:	486,0 m²
Spec. Capacity:	132 Wh/K pro m² TFA		
Overheating Limit:	25 °C		

	Building Element	Temperature Zone	Area m²		U-Value W/(m²K)		Red. Factor $f_{T,Summer}$		H_{Summer} Heat Conductance
1.	Exterior Wall - Ambien	A	383,3	*	0,092	*	1,00	=	35,3
2.	Exterior Wall - Ground	B	77,9	*	0,100	*	1,00	=	7,8
3.	Roof/Ceiling - Ambient	A	279,7	*	0,092	*	1,00	=	25,7
4.	Floor Slab	B	247,8	*	0,089	*	1,00	=	22,1
5.		A		*		*	1,00	=	
6.		A		*		*	1,00	=	
7.		X		*		*	0,75	=	
8.	Windows	A	65,4	*	0,687	*	1,00	=	44,9
9.	Exterior Door	A		*		*	1,00	=	
10.	Exterior TB (length/m)	A		*		*	1,00	=	
11.	Perimeter TB (length/m	P		*		*	1,00	=	
12.	Ground TB (length/m)	B		*		*	1,00	=	

Exterior Thermal Transmittance, $H_{T,e}$ 106,0 W/K

Ground Thermal Transmittance, $H_{T,g}$ 29,9 W/K

Heat Recovery Efficiency	η_{HR} 90%	Effective Air Volume V_V	A_{TFA} m²: 486,0	*	Clear Room Height m: 2,50	=	m³: 1215
SHX Efficiency	η^*_{SHX} 93%						

Summer Ventilation continuous ventilation to provide sufficient indoor air quality

Air Change Rate by Natural (Windows & Leakages) or Exhaust-Only Mechanical Ventilation, Summer: 0,07 1/h

Mechanical Ventilation Summer: 0,30 1/h | with HR (check if applicable)

	$n_{L,nat}$ 1/h		$n_{V,system}$ 1/h		Φ_{HR}			$n_{V,Rest}$ 1/h		1/h
Energetically Effective Airchange Rate n_V	0,074	+	0,300	* (1 -	0,000	)	+	0,000	=	0,374

	V_V m³		$n_{V,equi,fraction}$ 1/h		c_{Air} Wh/(m³K)		
Ventilation Transm. Ambient $H_{V,e}$	1215	*	0,095	*	0,33	=	37,9 W/K
Ventilation Transm. Ground $H_{V,g}$	1215	*	0,279	*	0,33	=	111,9 W/K

Additional Summer Ventilation for Cooling Temperature Amplitude Summer 7,8 K

Select: x Window Night Ventilation, Manual
Mechanical, Automatically Controlled Ventilation

Corresponding Air Change Rate 0,07 1/h
(for window ventilation: at 1 K temperature difference indoor - outdoor)

Minimum Acceptable Indoor Temperature 20,0 °C

	Orientation of the Area	Angle Factor Summer		Shading Factor Summer		Dirt		g-Value (perp. radiation)		Area m²		Portion of Glazing		Aperture m²
1.	North	0,9	*	0,94	*	0,95	*	0,50	*	10,5	*	67%	=	2,8
2.	East	0,9	*	0,95	*	0,95	*	0,50	*	17,2	*	77%	=	5,3
3.	South	0,9	*	0,44	*	0,95	*	0,50	*	33,9	*	68%	=	4,3
4.	West	0,9	*	0,84	*	0,95	*	0,50	*	3,8	*	55%	=	0,8
5.	Horizontal	0,9	*	1,00	*	0,95	*	0,00	*	0,0	*	0%	=	0,0
6	Sum Opaque Areas													2,0

Solar Aperture Total 15,3 | m²/m² 0,03

	Specif. Power q_I W/m²		A_{TFA} m²		W	W/m²
Internal Heat Gains Q_I	2,10	*	486	=	1021	2,1

Frequency of Overheating $h_{\vartheta \geq \vartheta max}$ **0,0%** **at the overheating limit ϑ_{max} = 25 °C**

If the "frequency over 25°C" exceeds 10%, additional measures to protect against summer heat waves are necessary.

	Solar Load kWh/d		1/k		Spec. Capacity Wh/(m²K)		A_{TFA} m²			
Daily Temperature Swing due to Solar Load	71,5	*	1000	/ (	132	*	486	) =	1,1	K

Passive House Planning

CALCULATING SUMMER SHADING FACTORS

Climate: N - Oslo

Building: LIPA Environmental centre

Latitude: 59,93

Summer! Orien-tation	Glazing Area	Summer Shading Factor
	m²	r_S
North	6,98	94%
East	13,20	95%
South	23,11	44%
West	2,13	84%
Horizontal	0,00	100%

Results from the Summer worksheet:
Frequency of Overheating $h_{\vartheta \geq \vartheta max}$ **0,0%**

Quantity	Description:	Deviation from North	Angle of Inclination from the Horizontal	Orientation	Glazing Width	Glazing Height	Glazing Area	Height of the Shading Object	Horizontal Distance	Reveal Depth	Distance from Glazing Edge to Reveal	Overhang Depth	Distance from Upper Glazing Edge to Overhang	Input Field Summer: Additional Shading Reduction Factor (Summer)	Input Field Summer: Temporary Shading Reduction Factor, z	Summer: Horizontal Shading Reduction Factor	Summer: Reveal Shading Reduction Factor	Summer: Overhang Shading Reduction Factor	Summer: Total Summer Shading Reduction Factor
		Degrees	Degrees			m		m	m	m	m	m	m	%	%	%	%	%	%
					w_G	h_G	A_G	h_{Hori}	d_{Hori}	o_{Reveal}	d_{Reveal}	o_{over}	d_{over}	r_{other}		r_H	r_R	r_O	r_S
6	S Ground Fl.	163	90	South	0,93	0,89	5,0			0,20	0,10				50%	100%	92%	100%	46%
7	S First Fl.	163	90	South	1,63	1,59	18,1			0,20	0,10			90%	50%	100%	95%	100%	43%
										0,20	0,10						62%		
1	N Ground Fl.	343	90	North	1,13	0,59	0,7			0,20	0,10					100%	93%	100%	93%
1	N Ground Fl.	343	90	North	1,73	2,19	3,8			0,20	0,10					100%	95%	100%	95%
1	N Ground Fl.	343	90	North	2,33	0,49	1,1			0,20	0,10					100%	96%	100%	96%
1	N Ground Fl.	343	90	North	0,93	1,49	1,4			0,20	0,10					100%	92%	100%	92%
1	East	73	90	East	0,83	0,49	0,4			0,20	0,10				90%	100%	93%	100%	84%
1	East	73	90	East	1,23	0,79	1,0			0,20	0,10				90%	100%	95%	100%	85%
1	East	73	90	East	1,23	1,69	2,1			0,20	0,10				90%	100%	95%	100%	85%
1	East	73	90	East	3,43	2,84	9,7			0,20	0,10					100%	98%	100%	98%
2	West	253	90	West	0,93	0,89	1,7			0,20	0,10				90%	100%	94%	100%	84%
1	West	253	90	West	0,53	0,89	0,5			0,20	0,10				90%	100%	90%	100%	81%

Passive House Planning

SUMMER VENTILATION

Building:	LIPA Environmental centre	Building Type/Use:	Dwelling
Location:	Linesoya	Building Volume	1215 m³

Description	Day GF	Day UF	Night				
Fraction of Opening Duration	13%	50%	100%				
Climate Boundary Conditions							
Temperature Diff Interior - Exterior	4	4	1				K
Wind Velocity	2	2	0				m/s
Window Group 1							
Quantity	6	7	3				
Clear Width	1,00	1,00	1,70				m
Clear Height	1,00	1,00	1,70				m
Tilting Windows?	x	x	x				
Opening Width (for tilting windows)	0,050	0,050	0,050				m
Window Group 2 (Cross Ventilation)							
Quantity			1				
Clear Width			1,80				m
Clear Height			2,30				m
Tilting Windows?			x				
Opening Width (for Tilting Windows)			0,050				m
Difference in Height to Window 1			0,00				m
Single-Sided Ventilation 1 - Airflow Volume	126	147	57	0	0	0	m³/h
Single-Sided Ventilation 2 - Airflow Volume	0	0	28	0	0	0	m³/h
Cross Ventilation Airflow Volume	126	147	85	0	0	0	m³/h
Contribution to Air Change Rate	0,01	0,06	0,07	0,00	0,00	0,00	1/h

Summary of Summer Ventilation Distribution

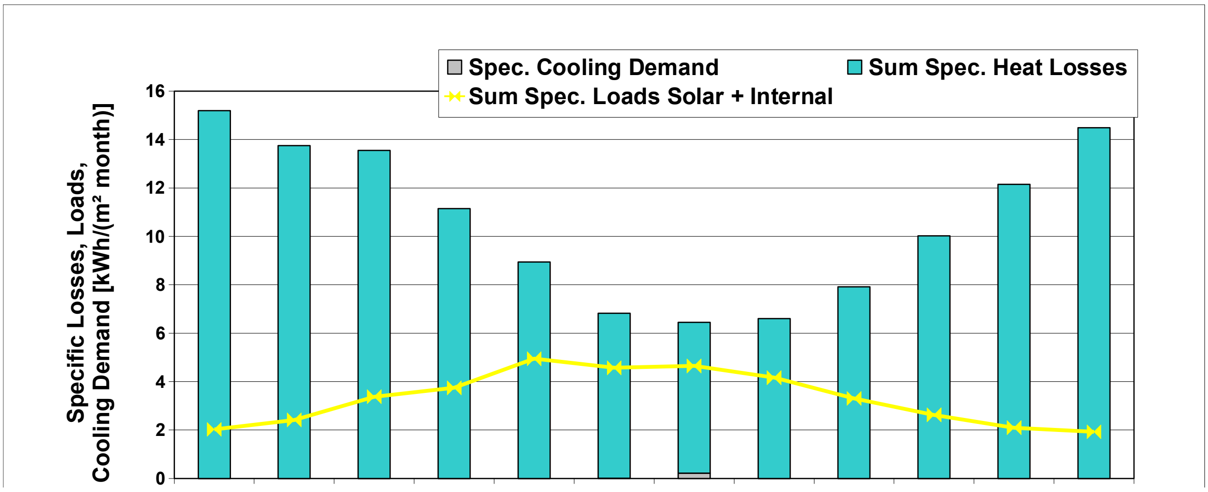
Description Ventilation Type	Daily Average Air Change Rate	
Nighttime Window Ventilation	0,07	1/h
Daytime Window Ventilation	0,07	1/h
		1/h

PASSIVE HOUSE PLANNING

SPECIFIC USEFUL COOLING DEMAND
MONTHLY METHOD

Climate:	N - Oslo	Interior Temperature:	25	°C
Building:	LIPA Environmental centre	Building Type/Use:	Dwelling	
Location:	Linesoya	Treated Floor Area A_{TFA}:	486	m²

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	
Heating Degree Hours - E	23,6	21,1	20,0	15,7	11,5	7,8	7,2	8,0	11,1	15,0	19,0	22,8	183	kKh
Heating Degree Hours - G	14,1	13,2	14,6	13,6	13,0	11,5	10,4	10,4	10,1	11,0	11,6	13,2	147	kKh
Losses - Exterior	3398	3035	2880	2261	1654	1124	1031	1157	1598	2164	2735	3288	26326	kWh
Losses - Ground	2003	1878	2074	1926	1849	1635	1477	1477	1434	1566	1652	1867	20839	kWh
Losses Summer Ventilatio	1984	1769	1630	1229	843	556	519	574	816	1142	1517	1885	14464	kWh
Sum Spec. Heat Losses	15,2	13,7	13,5	11,1	8,9	6,8	6,2	6,6	7,9	10,0	12,1	14,5	126,8	kWh/m²
Solar Load North	8	21	52	80	149	153	151	110	62	32	11	7	836	kWh
Solar Load East	26	84	206	325	539	520	492	381	219	111	37	21	2962	kWh
Solar Load South	156	297	451	446	583	476	511	486	409	279	189	124	4408	kWh
Solar Load West	11	27	51	65	100	82	88	79	52	28	15	8	606	kWh
Solar Load Horiz.	0	0	0	0	0	0	0	0	0	0	0	0	0	kWh
Solar Load Opaque	24	58	120	168	273	253	257	206	129	66	31	18	1604	kWh
Internal Heat Gains	759	686	759	735	759	735	759	759	735	759	735	759	8940	kWh
Sum Spec. Loads Solar +	2,0	2,4	3,4	3,7	4,9	4,6	4,6	4,2	3,3	2,6	2,1	1,9	39,8	kWh/m²
Utilisation Factor Losses	13%	18%	25%	34%	55%	67%	71%	63%	42%	26%	17%	13%	31%	
Useful Cooling Energy De	0	0	0	0	0	2	107	1	0	0	0	0	110	kWh
Spec. Cooling Demand	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,2**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,2**	kWh/m²



Passive House Planning

COMPRESSOR COOLING UNITS

Climate:	N - Oslo		Interior Temperature Summer:	25 °C
Building:	LIPA Environmental centre		Building Type/Use:	Dwelling
Location:	Linesoya		Treated Floor Area A_{TFA}:	486,0 m²

	A_{TFA} (m²)		Clear Room Height (m)		(m³)
Effective Air Volume V_V	486	*	2,50	=	1215

	$n_{V,system}$ (1/h)		Φ_{HR} Efficiency Humidity Rec.			(1/h)
Hygrically Effective Mech. Air Change Rate Summer	0,300	* (1 -		)	=	0,300

	$n_{V,nat}$ (1/h)		$n_{V,Res}$ (1/h)		$n_{Night,Windows}$ (1/h)		$n_{Night,mechanical}$ (1/h)		
Direct Ambient Air Change Rate Summer	0,074	+	0,000	+	0,131	+	0,000	=	0,205

Ambient Air Change Rate Summer — Total 0,50 1/h

[x] Supply Air Cooling
check as appropriate

On/Off Mode (check as appropriate)	x	
Minimum Temperature of Cooling Coil Surface	0	°C

[ ] Recirculation Cooling
check as appropriate

On/Off Mode (check as appropriate)	x	
Minimum Temperature of Cooling Coil Surface	10	°C
Volume Flow Rate	300	m³/h

[ ] Additional Dehumidification
check as appropriate

Max. Humidity Ratio	12	g/kg
Humidity Sources	2	g/(m²h)
Humidity Capacity Building	700	g/(g/kg)/m²
Humidity at Beginning of Cooling Period	8	g/kg

[ ] Panel Cooling
check as appropriate

	sensible	latent		Sensible Fraction
Useful Cooling Demand	0,2	0,0		
of which				
Supply Air Cooling	0,2	0,0	kWh/(m²a)	95,0%
Recirculation Cooling			kWh/(m²a)	
Dehumidification			kWh/(m²a)	
Remaining for Panel Cooling			kWh/(m²a)	
Total	**0,2**	**0,0**	kWh/(m²a)	95,0%
Unsatisfied Demand	0,0	0,0	kWh/(m²a)	

Passive House Planning

COOLING LOAD

Building:	LIPA Environmental centre		Building Type/Use:	Dwelling	Interior Temperature: 25 °C
Location:	Linesoya		Treated Floor Area A_{TFA}:	486,0 m²	
Spec. Capacity:	132	Wh/(m²K) (Enter in "Summer" worksheet.)	Climate (Cooling Load):	Nord- und westdeutsches Tiefland, z.B. Ha	

	Ambient Air		Sky		Ground		Radiation:	North	East	South	West	Horizontal	
Design Temperature:	24,0	°C	14,2	°C	11,7	°C		100	220	210	220	350	W/m²

	Building Elements	Temperature Zone	Area m²		U-Value W/(m²K)		Factor Always 1 (except "X")		TempDiff K		W
1.	Exterior Wall - Ambient	A	383,3	*	0,092	*	1,00	*	-1,0	=	-35
2.	Exterior Wall - Ground	B	77,9	*	0,100	*	1,00	*	-13,3	=	-104
3.	Roof/Ceiling - Ambient	A	279,7	*	0,092	*	1,00	*	-1,0	=	-26
4.	Floor Slab	B	247,8	*	0,089	*	1,00	*	-13,3	=	-294
5.		A		*		*	1,00	*	-1,0	=	
6.		A		*		*	1,00	*	-1,0	=	
7.		X		*		*	0,75	*	-1,0	=	
8.	Windows	A	65,4	*	0,687	*	1,00	*	-1,0	=	-45
9.	Exterior Door	A		*		*	1,00	*	-1,0	=	
10.	Exterior TB (length/m)	A		*		*	1,00	*	-1,0	=	
11.	Perimeter TB (length/m)	P		*		*	1,00	*	-13,3	=	
12.	Ground TB (length/m)	B		*		*	1,00	*	-13,3	=	
13.	House/DU Partition Wall	I		*		*	1,00	*	3,0	=	
			$L_{ambient}$ W/K		TempDiff K		L_{Sky} W/K		TempDiff K		
14.	Radiation Correction		-9,3	*	-1,0	+	9,3	*	-10,8	=	-91

Transmission Heat Losses P_T — Total = **-594**

Ventilation System:

	A_{TFA} m²		Clear Room Height m		m³
Effective Air Volume, V_V	486,0	*	2,50	=	1215

	Vent. Transm. W/K		TempDiff kKh/a		W
Exterior	37,9	*	-1,0	=	-38
Ground	111,9	*	-13,3	=	-1486

Additional Summer Ventilation:

x	Window Night Ventilation, Manual	Corresponding Air Change Rate	0,07	1/h
	Mechanical, Automatically Controlled Ventilation	Minimum Indoor Temperature	20,0	°C

		kWh/d		kh/d		W
Heat Removal Cooling Design Day	Window Ventilation	-4,6	/	0,024	=	-194
(from Cooling worksheet)	Automatic Night Ventilation	0,0	/	0,024	=	0

Ventilation Heat Load P_V — Total = W **-1717**

	Orientation of the Area	Area m²		g-Value (perp. radiation)		Reduction Factor		Radiation W/m²		P_S W
1.	North	10,5	*	0,5	*	0,54	*	108	=	304
2.	East	17,2	*	0,5	*	0,62	*	198	=	1059
3.	South	33,9	*	0,5	*	0,25	*	213	=	917
4.	West	3,8	*	0,5	*	0,40	*	231	=	175
5.	Horizontal	0,0	*	0,0	*	0,40	*	350	=	0
6.	Sum Opaque Areas									526

Heat Gain - Solar Heat Load, P_S — Total = **2981**

	Spec. Power W/m²		A_{TFA} m²		P_I W
Internal Heat Load P_I	3,1	*	486	=	**1507**

Cooling Load P_C — $P_T + P_V + P_S + P_I$ = **2176** W

Specific Maximum Cooling Load P_C / A_{EB} = **4,5** W/m²

	Solar Load W		Time h/d		Spec. Capacity Wh/(m²K)		A_{TFA} m²			
Daily Temperature Swing due to Solar Load	2980,6	*	24	/ (	132	*	486	) =	1,1	K

Passive House Planning

HEAT DISTRIBUTION AND DHW SYSTEM

Building:	LIPA Environmental centre	
Location:	Linesoya	
Interior Temperature:	20	°C
Building Type/Use:	Dwelling	
Treated Floor Area A_{TFA}:	486	m²
Occupancy:	13,9	Pers
Number of Residences:	1	
Annual Heat Demand $q_{Heating}$	7352	kWh/a
Length of Heating Period:	205	d
Average Heat Load P_{ave}:	1,5	kW
Marginal Utilisability of Additional Heat Gains:	86%	

			Parts: Warm Region	Cold Region		Total		
Space Heat Distribution			1	2	3			
Length of Distribution Pipes	L_H *(Project)*						m	
Heat Loss Coefficient per m Pipe	Ψ *(Project)*						W/(mK)	
Temperature of the Room Through Which the Pipes	ϑ_X *Mechanical Room*		20				°C	
Design Flow Temperature	ϑ_{dist} *Flow, Design Value*						°C	
Design System Heat Load	$P_{heating}$ *(exist./calc.)*						kW	
Flow Temperature Control (check)								
Design Return Temperature	ϑ_R	$=0.714*(\vartheta_{dist}-20)+20$					°C	
Annual Heat Emission per m of Plumbing	q^*_{HL}	$=\Psi\,(\vartheta_m-\vartheta_X)\,t_{Heating}*0.024$				Total 1,2,3	kWh/(m·a)	
Possible Utilization Factor of Released Heat	η_G						-	
Annual Losses	Q_{HL}	$= L_H \cdot q^*_{HL} \cdot (1-\eta_G)$	0	0	0	0	kWh/a	
Specif. Losses	q_{HL}	$= \Sigma Q_{HL} / A_{TFA}$					kWh/(m²a)	0,0
Utilisation Factor of Space Heat Distribution	$h_{a,HL}$	$= q_H / (q_H + q_{HL})$				100%	-	

			Total		
DHW: Standard Useful Heat					
DHW Consumption per Person and Day (60 °C)	V_{DHW} *(Project or Average Value 25 Litres/P/d)*		25,0	Litre/Person/d	
Average Cold Water Temperature of the Supply	ϑ_{DW} *Temperature of Drinking Water (10°)*		10,0	°C	
DHW Non-Electric Wash and Dish	*(Electricity worksheet)*		1001	kWh/a	
Useful Heat - DHW	Q_{DHW}		8350	kWh/a	
Specif. Useful Heat - DHW	q_{DHW}	$= Q_{DHW} / A_{TFA}$		kWh/(m²a)	17,2

DHW Distribution and Storage			Warm Region	Cold Region		Total		
Length of Circulation Pipes (Flow + Return)	L_{HS} *(Project)*		12,0				m	
Heat Loss Coefficient per m Pipe	Ψ *(Project)*		0,140				W/m/K	
Temperature of the Room Through Which the Pipes	ϑ_X *Mechanical Room*		20				°C	
Design Flow Temperature	ϑ_{dist} *Flow, Design Value*		60,0				°C	
Daily circulation period of operation.	td_{Circ} *(Project)*		18,0				h/d	
Design Return Temperature	ϑ_R	$=0.875*(\vartheta_{dist}-20)+20$	55				°C	
Circulation period of operation per year	t_{Circ}	$= 365\ td_{Circ}$	6570				h/a	
Annual Heat Released per m of Pipe	q^*_Z	$= \Psi\,(\vartheta_m-\vartheta_X)\,t_{Circ}$	34,5				kWh/m/a	
Possible Utilization Factor of Released Heat	η_{GDHW}	$=t_{heating}/365d * \eta_G$	48,3%				-	
Annual Heat Loss from Circulation Lines	Q_Z	$= L_{HS} \cdot q^*_Z \cdot (1-\eta_{GDHW})$	214			214	kWh/a	
Total Length of Individual Pipes	L_U *(Project)*		9,00				m	
Exterior Pipe Diameter	d_{U_Pipe} *(Project)*		0,012				m	
Heat Loss Per Tap Opening	$q_{Individual}$	$=(c_{pH2O}V_{H2O}+c_{pMat}V_{Mat})(\vartheta_{dist}-\vartheta_X)$	0,0322				kWh/tap opening	
Occupancy Coefficient	n_{Tap}	$= n_{Pers} \cdot 3 \cdot 365 / n_{LU}$	15205				Tap openings per year	
Annual Heat Loss	q_U	$= n_{Tap} \cdot q_{Individual}$	489,9				kWh/a	
Possible Utilization Factor of Released Heat	η_{G_U}	$=t_{heating}/8760*\eta_G$	48,3%				-	
Annual Heat Loss of Individual Pipes	Q_U	$= q_U \cdot (1-\eta_{G\_U})$	253,3			253	kWh/a	
						Total 1,2,3		
Average Heat Released From Storage	P_S		80,0				W	
Possible Utilization Factor of Released Heat	η_{G_S}	$=t_{heating}/8760*\eta_G$	48,3%					
Annual Heat Losses from Storage	Q_S	$= P_S \cdot 8.760\ kh \cdot (1-\eta_{G\_S})$	362,4			362	kWh/a	
						Total 1,2,3		
Total Heat Losses of the DHW System	Q_{WL}	$= Q_Z+Q_U+Q_S$				830	kWh/a	
Specif. Losses of the DHW System	q_{WL}	$= Q_{WL} / A_{TFA}$					kWh/(m²a)	1,7
Utilisation Factor DHW Distrib and Storage	$\eta_{a,WL}$	$= q_{DHW} / (q_{DHW} + q_{WV})$				91,0%	-	
Total Heat Demand of DHW system	Q_{gDHW}	$= Q_{DHW}+Q_{WL}$				9179	kWh/a	
Total Spec. Heat Demand of DHW System	q_{gDHW}	$= Q_{gDHW} / A_{TFA}$					kWh/(m²a)	18,9

Passive House Planning

LECTRICITY DEMAND

Building: LIPA Environmental centre

# Households	1	HH
# Persons	13,9	P
# Living Area	486	m²
# Annual Heat Demand	15	kWh/(m²a)

Solar Fraction of DHW Wash&Dish	40%
Marginal Performance Ratio DHW	42%
Marginal Performance Ratio Heating	31%

Prim. Energy Factors:			
	Electricity	2,7	kWh/kWh
	Natural Gas	1,1	kWh/kWh
Energy Carrier for Space Heating/DHW:		2,7	2,7

Column Nr.	1	2	3			4	5		6		7	8	8a	9	10	11	12	13	14
Application	Used ? (1/0)	Within the Thermal Envelope? (1/0)	Norm Demand			Utilization Factor	Frequency		Reference Quantity		Useful Energy (kWh/a)	Electric Fraction	Non-Electric Fraction	Electricity Demand (kWh/a)	Additional Demand	Marginal Performance Ratio	Solar Fraction	Non-Electric Demand (kWh/a)	Primary Energy-Demand (kWh/a)
Dishwashing	1	1	1,10	kWh/Use		1,00	65	/(P*a)	13,9	P	993	50%		496					1340
DHW Connection													50%		0,30	0,42	0,40	160	433
Clothes Washing	1	1	0,95	kWh/Use		1,00	57	/(P*a)	13,9	P	752	55%		414					1117
DHW Connection													45%		0,05	0,42	0,40	88	238
Clothes Drying with:	1	0	0,00	kWh/Use	Residual dampness 0,60	0,88	57	/(P*a)	13,9	P	0	0%		0					0
Clothesline											0		0%			1,00		0	0
Energy Consumed by Evaporation	1	0	0,00	kWh/Use		0,60	57	/(P*a)	13,9	P	0		100%		0,00	0,31	0,67	0	0
Refrigerating	1	1	0,28	kWh/d		1,00	365	d/a	1	HH	102	100%		102					276
Freezing	1	0	0,55	kWh/d		0,90	365	d/a	1	HH	181	100%		181					488
or Combined Unit	0	1	0,70	kWh/d		1,00	365	d/a	1	HH	0	100%		0					0
Cooking with:	1	1	0,25	kWh/Use		1,00	500	/(P*a)	13,9	P	1736	100%		1736					4686
Electricity					Percentage CFLs								0%					0	0
Lighting	1	1	21	W	80%	1,00	2,90	kh/(P*a)	13,9	P	838	100%		838					2261
Consumer Electronics	1	1	80	W		1,00	0,55	kh/(P*a)	13,9	P	611	100%		611					1650
Small Appliances, etc	1	1	50	kWh		1,00	1,00	/(P*a)	13,9	P	694	100%		694					1875
Total Aux. Electricity											1107			1107					2990
Other:																			
											0			0					0
											0			0					0
											0			0					0
Total											7014 kWh			6179 kWh	DHW Non-Electric - Wash&Dish	1001		kWh 249	17354
Specific Demand														12,7 kWh/(m²a)	Non-Renewable Non-Electric DHW Wash&Dish	1,2		kWh/(m²a) 0,5	35,7
Recommended Maximum Value														18					50

Passive House Planning

HOT WATER PROVIDED BY SOLAR

Building:	LIPA Environmental centre	Building Type/Use:	Dwelling
Location:	Linesoya	Treated Floor Area A_{TFA}:	486,0 m²

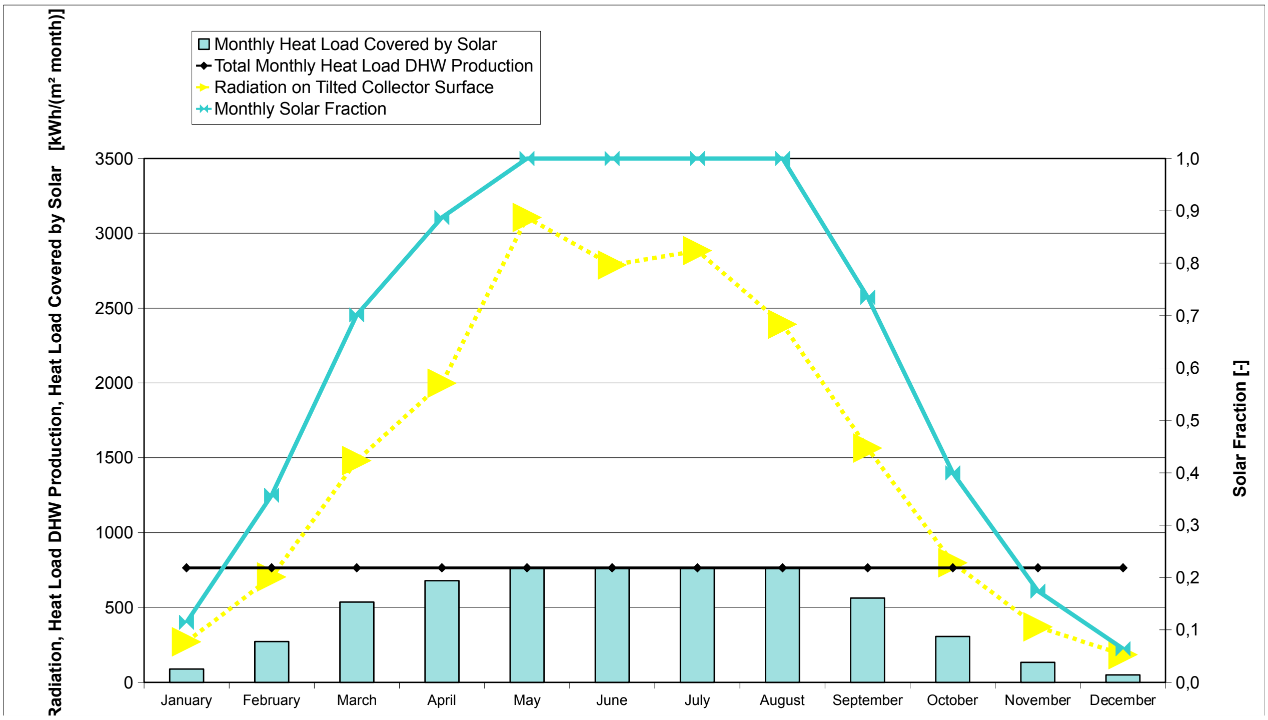
Solar Fraction with DHW Demand including Washing and Dish-Washing

Heat Demand DHW	q_{gDHW}	9179	kWh/a	from DHW+Distribution worksheet
Latitude:		59,9	°	from Climate Data worksheet
Selection of collector from list (see below):		8	Selection:	
Solar Collector Area		15,00	m²	
Deviation from North		163	°	
Angle of Inclination from the Horizontal		27	°	
Height of the Collector Field		7	m	
Height of Horizon	h_{Hori}		m	
Horizontal Distance	a_{Hori}		m	
Additional Reduction Factor Shading	r_{other}		%	
Occupancy		13,9	Persons	
Specific Collector Area		1,1	m²/Pers	

Estimated Solar Fraction of DHW Production	**62%**			
Solar Contribution to Useful Heat	**5686**	kWh/a	**12**	kWh/(m²a)

Secondary Calculation of Storage Losses

Selection of DHW storage from list (see below):	14	Selection:	anger
Total Storage Volume	490	litre	
Volume Standby Part (above)	147	litre	
Volume Solar Part (below)	343	litre	
Specific Heat Losses Storage (total)	2,0	W/K	
Typical Temperature DHW	60	°C	
Room Temperature	20	°C	
Storage Heat Losses (Standby Part Only)	**56**	W	
Total Storage Heat Losses	**80**	W	



Passive House Planning

AUXILIARY ELECTRICITY

Building: LIPA Environmental centre

1	Living Area	486	m²
2	Heating Period	205	d
3	Air Volume	1215	m³
4	Dwelling Units	1	HH
5	Enclosed Volume	1960	m³

Operation Vent. System Winter	4,91	kh/a
Operation Vent. System Summer	3,85	kh/a
Air Change Rate	0,30	h^{-1}
Defrosting HX from	-3,0	°C

Primary Energy Factor - Electricity	2,7	kWh/kWh
Annual Space Heat Demand	15	kWh/(m²a)
Boiler Rated Power	3	kW
DHW System Heat Demand	9179	kWh/a
Design Flow Temperature	0	°C

Column Nr.	1	2	3			4			5			6			7		8		9		10	11
Application	Used ? (1/0)	Within the Thermal Envelope? (1/0)	Norm Demand			Utilization Factor			Period of Operation			Reference Size			Electricity Demand (kWh/a)		Available as Interior Heat		Used During Time Period (kh/a)		Internal Heat Source (W)	Primary Energy Demand (kWh/a)
Ventilation System																						
Winter Ventilation	1	1	0,40	Wh/m³	*	0,30	h^{-1}	*	4,9	kh/a	*	1215	m³	=	716		considered in heat recovery efficiency					1932
Summer Ventilation	0	1	0,40	Wh/m³	*	0,30	h^{-1}	*	3,9	kh/a	*	1215	m³	=	0		no summer contribution to IHG					0
Defroster HX	0	0	947	W	*	1,00		*	0,1	kh/a	*	1		=	0	*	1,0	/	4,91	=	0	0
Heating System						Controlled/Uncontrolled (1/0)																
Enter the Rated Power of the Pump			21	W		1																
Circulation Pump	0	0	21	W	*	0,7		*	4,9	kh/a	*	1		=	0	*	1,0	/	4,91	=	0	0
Boiler Electricity Consumption at 30% Load				W																		
Aux. Energy - Heat. Boiler	0	0	25	W	*	1,00		*	0,00	kh/a	*	1		=	0	*	1,0	/	4,91	=	0	0
DHW system																						
Enter Average Power Consumption of Pump			6	W																		
Circulation Pump	1	1	6	W	*	1,00		*	6,1	kh/a	*	1		=	37	*	0,6	/	8,76	=	3	99
Enter the Rated Power of the Pump				W																		
Storage Load Pump DHW	1	1	81	W	*	1,00		*	3,1	kh/a	*	1		=	248	*	1,0	/	4,91	=	50	669
Boiler Electricity Consumption at 100% Load				W																		
DHW Boiler Aux. Energy	0	1	76	W	*	1,00		*	0,0	kh/a	*	1		=	0	*	1,0	/	4,91	=	0	0
Enter the Rated Power of the Solar DHW Pump				W																		
Solar Aux Electricity	1	1	61	W	*	1,00		*	1,8	kh/a	*	1		=	107	*	0,6	/	8,76	=	8	290
Misc. Aux. Electricity																						
Misc. Aux. Electricity	0	0	30	kWh/a	*	1,00		*	1,0		*	1	HH	=	0	*	1,0	/	8,76	=	0	0
Total															1107						61	2990
Specific Demand	kWh/(m²a)		Divide by Living Area:												2,3							6,2

Passive House Planning

PRIMARY ENERGY VALUE

Building:	LIPA Environmental centre	Building Type/Use:	Dwelling
Location:	Linesoya	Treated Floor Area A_{TFA}:	486 m²
		Space Heat Demand incl. Distribution	15 kWh/(m²a)
		Useful Cooling Demand:	0 kWh/(m²a)

			Final Energy	Primary Energy	Emissions CO_2-Equivalent
			kWh/(m²a)	kWh/(m²a)	kg/(m²a)
Electricity Demand (without Heat Pump)				PE Value	CO_2-Emissions Factor (CO_2-Equivalent)
Covered Fraction of Space Heat Demand		*(Project)*	0%	kWh/kWh	g/kWh
Covered Fraction of DHW Demand		*(Project)*	0%	2,7	680
Direct Electric Heating	$Q_{H,de}$		0,0	0,0	0,0
DHW Production, Direct Electric (without Wash&Dish)	$Q_{DHW,de}$	*(DHW+Distribution, SolarDHW)*	0,0	0,0	0,0
Electric Postheating DHW Wash&Dish		*(Electricity, SolarDHW)*	0,0	0,0	0,0
Electricity Demand Household Appliances	Q_{EHH}	*(Electricity worksheet)*	10,4	28,2	7,1
Electricity Demand - Auxiliary Electricity			2,3	6,2	1,5
Total Electricity Demand (without Heat Pump)			**12,7**	**34,3**	**8,6**

Heat Pump				PE Value	CO_2-Emission Factor (CO_2-Equivalent)
Covered Fraction of Space Heat Demand		*(Project)*	100%	kWh/kWh	g/kWh
Covered Fraction of DHW Demand		*(Project)*	100%	2,7	680
Energy Carrier - Supplementary Heating			Electricity	2,7	680
Annual Coefficient of Performance - Heat Pump		*Separate Calculation*	3,20		
Total System Performance Ratio of Heat Generator		*Separate Calculation*	0,45		
Electricity Demand Heat Pump (without DHW Wash&Dish)	Q_{HP}		9,6	24,6	6,2
Non-Electric Demand, DHW Wash&Dish		*(Electricity worksheet)*	0,5	1,4	0,3
Total Electricity Demand Heat Pump			**10,1**	**27,4**	**6,9**

Compact Heat Pump Unit				PE Value	CO_2-Emission Factor (CO_2-Equivalent)
Covered Fraction of Space Heat Demand		*(Project)*	0%	kWh/kWh	g/kWh
Covered Fraction of DHW Demand		*(Project)*	0%	2,7	680
Energy Carrier - Supplementary Heating			Electricity	2,7	680
COP Heat Pump Heating		*(Compact worksheet)*	0,0		
COP Heat Pump DHW		*(Compact worksheet)*	0,0		
Performance Ratio of Heat Generator (Verification)		*(Compact worksheet)*			
Performance Ratio of Heat Generator (Planning)		*(Compact worksheet)*			
Electricity Demand Heat Pump (without DHW Wash&Dish)	Q_{HP}	*(Compact worksheet)*	0,0	0,0	0,0
Non-Electric Demand, DHW Wash&Dish			0,0	0,0	0,0
Total Compact Unit		*(Compact worksheet)*	**0,0**	**0,0**	**0,0**

Boiler				PE Value	CO_2-Emission Factor (CO_2-Equivalent)
Covered Fraction of Space Heat Demand		*(Project)*	0%	kWh/kWh	g/kWh
Covered Fraction of DHW Demand		*(Project)*	0%	1,1	250
Boiler Type		*(Boiler worksheet)*			
Utilisation Factor Heat Generator		*(Boiler worksheet)*	0%		
Annual Energy Demand (without DHW Wash&Dish)		*(Boiler worksheet)*	0,0	0,0	0,0
Non-Electric Demand, DHW Wash&Dish		*(Electricity worksheet)*	0,0	0,0	0,0
Total Heating Oil/Gas/Wood			**0,0**	**0,0**	**0,0**

District Heat				PE Value	CO_2-Emission Factor (CO_2-Equivalent)
Covered Fraction of Space Heat Demand		*(Project)*	0%	kWh/kWh	g/kWh
Covered Fraction of DHW Demand		*(Project)*	0%	0,7	-70
Heat Source		*(District Heat worksheet)*			
Utilisation Factor Heat Generator		*(District Heat worksheet)*	95%		
Heat Demand District Heat (without DHW Wash&Dish)		*(District Heat worksheet)*	0,0	0,0	0,0
Non-Electric Demand, DHW Wash&Dish		*(Electricity worksheet)*	0,0	0,0	0,0
Total District Heat			**0,0**	**0,0**	**0,0**

Other				PE Value	CO_2-Emission Factor (CO_2-Equivalent)
Covered Fraction of Space Heat Demand		*(Project)*	0%	kWh/kWh	g/kWh
Covered Fraction of DHW Demand		*(Project)*	0%	0,2	55
Heat Source		*(Project)*	Wood		
Utilisation Factor Heat Generator		*(Project)*	74%		
Annual Energy Demand, Space Heating			0,0	0,0	0,0
Annual Energy Demand, DHW (without DHW Wash&Dish)			0,0	0,0	0,0
Non-Electric Demand, DHW Wash&Dish		*(Electricity worksheet)*	0,0	0,0	0,0
Non-Electric Demand Cooking/Drying (Gas)		*(Blatt Strom)*	0,0	0,0	0,0
Total - Other			**0,0**	**0,0**	**0,0**

Cooling with Electric Heat Pump				PE Value	CO_2-Emission Factor (CO_2-Equivalent)
				kWh/kWh	g/kWh
Covered Fraction of Cooling Demand		*(Project)*	100%	2,7	680
Heat Source			Electricity		
Annual Cooling COP			3,3		
Energy Demand Space Cooling			**0,1**	**0,2**	**0,0**

Heating, Cooling, DHW, Auxiliary and Household Electricity			**22,9**	**61,9**	**15,6**
Total PE Value		**61,9**	kWh/(m²a)		
Total Emissions CO_2-Equivalent		**15,6**	kg/(m²a)		(Yes/No)
Primary Energy Requirement			120	kWh/(m²a)	**Yes**

Heating, DHW, Auxiliary Electricity (No Household Applications)			**11,9**	**30,8**	**7,8**
Specific PE Demand - Mechanical System		**30,8**	kWh/(m²a)		
Total Emissions CO_2-Equivalent		**7,8**	kg/(m²a)		

Solar Electricity			kWh/a	PE Value (Savings)	CO_2-Emission Factor
Planned Annual Electricity Generation		*Separate Calculation*	11838	kWh/kWh	g/kWh
				0,7	250
Specific Demand			**24,4**	**17,1**	**6,1**
PE Value: Conservation by Solar Electricity		**48,7**	kWh/(m²a)		
CO_2-Emissions Avoided Due to Solar Electricity		**10,5**	kg/(m²a)		