MASTER ENERGY REPORT

Business Academy Aarhus

Architectural Technology and Construction Management

3rd semester

13bk2ena, group no 2

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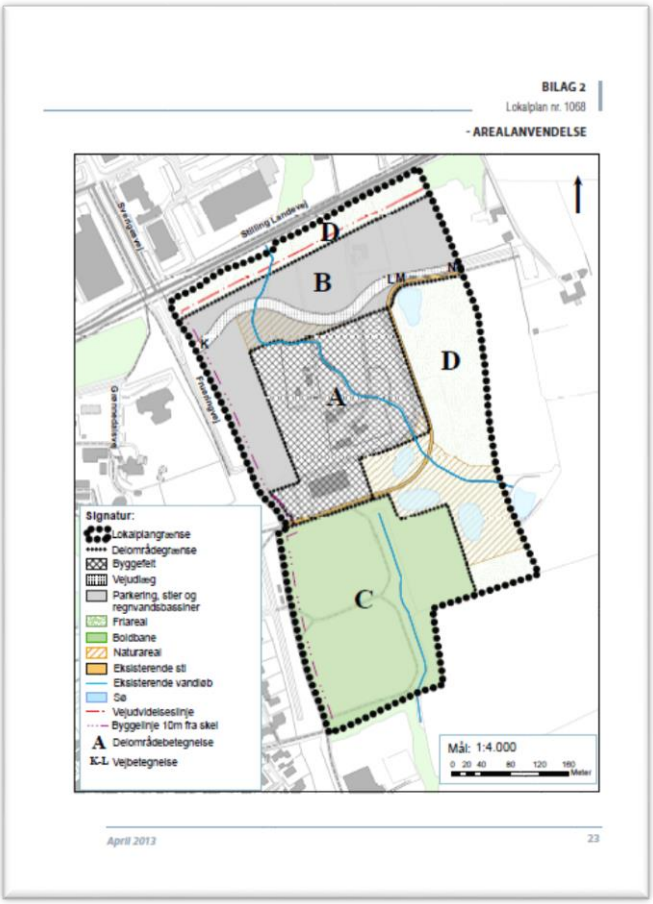
Content

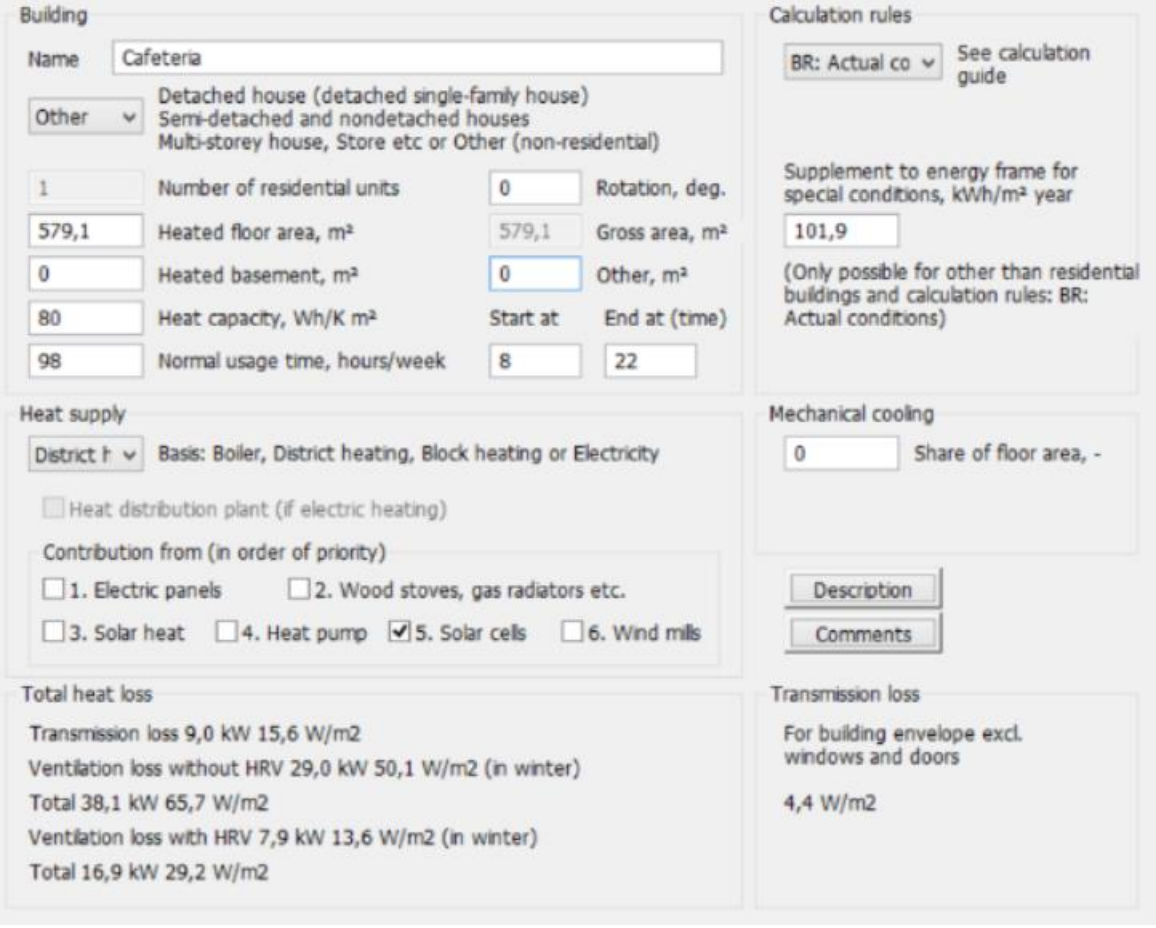
Description of the building

- Object is the industrialized building which consist multi-purpose hall with office part and locker rooms, long hallway and smaller part with cafeteria and meeting rooms.
- The construction of the building is based on prefabricated elements. Cafeteria part is made of wooden lightweight construction.
- Sports facility is located in Skanderborg, Denmark.
- From the requirements the building must be performed by energy class 2015.



The building's heated floor area and the heat capacity

The building is considered as a other it means that is non-residential building. The heated floor area amounts to 579,1 m^2. Heat capacity is the physical quantity which we can measure and it is the ratio of heat (added or subtract from an object) to the temperature change. Heat capacity is based on SBI213 and our café part consists medium-light type of building components and the heat capacity is 80 Wh/Km^2. The building is used only during the day, at night is closed. It means that the occupation time equals 98 hours (seven days in a week multiplied with 14 hours per day). The heat supply in the object is district heating. We also implemented solar cells on the south part of the sloped roof. The building is placed exactly to face north we do not have any rotation factors. We also made supplement to energy frame for special conditions which is the ventilation (F_o – working time and $q_{m,s}$ – natural ventilation in summer) also normal usage time of the building. Our supplement equal 101,9 kWh/m^2. Transmission loss result for the building is 4,4 W/m^2, which fulfills the building regulations 2010 demands (the demand is 5 $W/m^{2)}$.



Area and u-values

The table shows the building's components that influence the total energy result and transmission loss. U-values have been calculated according DS418. Areas are based on the Revit project. From SBI213 guidance we took B factor which is 1. Temperatures conventionally adopted as inside is 20^0C degrees and outside -12^0C. But Dim. Outside for the floor is 10^0C because the floor is connected with the soil. Loss is calculated automatically by the program.

	External walls, roofs and floors	Area (m2)	U (W/m2K)	b	Ht (W/K)	Dim.Inside (C)	Dim.Outside (C)	Loss (W)
		1888,9		CtrlClick	216,291			6339,66
1	External walls LW	728,6	0,18	1,00	131,148	20	-12	4196,74
2	Roof lightweight construction	581,2	0,09	1,00	52,308	20	-12	1673,86
3	Floor	579,1	0,081	0,7	32,835	20	10	469,071

The length of the linear loss and Ψ-values

Lengths of foundation and windows/door joints are based on our calculations from Revit file but the U-value is taken from DS418. B factor as well temperatures are the same as in the area and u-value for building components table.

	Foundations and joints at windows	l (m)	Loss (W/mK)	b	Ht (W/K)	Dim.Inside (C)	Dim.Outside (C)	Loss (W)
		182,585		CtrlClick	28,6538			916,923
1	Foundations	165,545	0,17	1,00	28,1427	20	-12	900,565
2	Joints around windows	17,04	0,03	1,00	0,5112	20	-12	16,3584

Windows

Window table shows all the different windows around the café part. Section called “Number” says how many of that specific windows are in whole construction. Orientation says how exposed the window is. The window’s slope compares with horizontal. Our windows have slope 90 degree it means that they are vertical. Area was calculated in Revit program. U-values are taken from the producers website. Temperature factor is the same as in the previous examples. G factor (solar transmittance) is 0,63 based on the information given in SBI213 also could be given by the producer. Our windows and doors contains wooden frame and big glass part so factor called F_f (glazing part) is 80%. The windows which have shading F_s factor are on the southern part of the building and its have shadows from east and west side with the horizon about 30 degrees. F_c – Solar screening factor equals 0.4 because we need to have curtain or blinds because without them the building will be heated to much. Loss is calculated automatically.

	Windows and outer doors	Number	Orient	Inclination	Area (m2)	U (W/m2K)	b	Ht (W/K)	Ff (-)	g (-)	Shading	Fc (-)	Dim.Inside	Dim.Outside	Loss (W)	Ext
		25			69,254		CtrlClick	23,6215			CtrlClick				755,89	0/1
1	East windows	4	E	90	1,068	0,075	1,00	0,3204	0,8	0,63	Default	0,4	20	-12	10,2528	0
2	West windows	4	W	90	1,068	0,075	1,00	0,3204	0,8	0,63	Default	0,4	20	-12	10,2528	0
3	South windows	2	S	90	5,5	0,075	1,00	0,825	0,8	0,63	Default eas	0,4	20	-12	26,4	0
4	South windows	2	S	90	2,26	0,075	1,00	0,339	0,8	0,63	Default eas	0,4	20	-12	10,848	0
5	South windows	1	S	90	1,21	0,075	1,00	0,09075	0,8	0,63	Default wes	0,4	20	-12	2,904	0
6	South windows	2	S	90	2,73	0,075	1,00	0,4095	0,8	0,63	Default wes	0,4	20	-12	13,104	0
7	South windows	1	S	90	8,49	0,075	1,00	0,63675	0,8	0,63	Default wes	0,4	20	-12	20,376	0
8	South windows	3	S	90	4,55	0,075	1,00	1,02375	0,8	0,63	Default wes	0,4	20	-12	32,76	0
9	South door	3	S	90	3,64	1,2	1,00	13,104	0,8	0,63		0,4	20	-12	419,328	0
10	South door	3	S	90	1,82	1,2	1,00	6,552	0,8	0,63		0,4	20	-12	209,664	0

Ventilation

The most parts of café area have mechanical ventilation as well natural ventilation provided by windows and doors, only technic room has natural ventilation. All figures are taken from the SBI 213 guidelines. The only one thing which we need to make bigger $g_{n,s}$ ()natural ventilation at summer factor is 1,6 l/s m^2 (in cafeteria and meeting rooms) because we want to achieve excessive “0” in rooms. This factor is not a part of a mechanical ventilation. It presents air vents which is open only in a summer to have better infiltration.

	Ventilation	Area (m2)	Fo, -	qm (l/s m2)	n vgv (-)	ti (°C)	El-HC	qn (l/s m2)	qi,n (l/s m2)	SEL (kJ/m3)	qm,s (l/s m2)	qn,s (l/s m2)	qm,n (l/s m2)	qn,n (l/s m2)
	Zone	509,9		Winter			0/1	Winter	Winter		Summer	Summer	Night	Night
1	Toilets	12,1	1	0,8	0,8	18	0	0,13	0,09	1,8	0,8	0,13	0	0,09
2	Cafeteria	248,3	1	1,015	0,8	18	0	0,13	0,09	1,8	1,015	1,6	0	0,09
3	Technic room	34,4	0	0	0	0	0	0,3	0,3	0	0	0,3	0	0,3
4	Meeting rooms	249,5	1	1,69	0,8	18	0	0,13	0,09	1,8	1,69	1,6	0	0,09

That table shows the air flow for each room which we calculate according to the tables "determination of airflow/ventilation rate".

Room	m2	Air flow (l/s/m2)	Air amount (m3/s)	Energy frame (l/s/m2)
Cafe	247.2	4	0.98	4
Storage	35	1	0.035	1
Techniacal room	21.6	natural ventilation		
H-Wc	7	10	0.01	1.43
Storage	11	1	0.011	1
Wc 1	2.5	10	0.01	4
Wc 2	2.5	10	0.01	4
Meeting room 1	52.4	6	0.31	6
Meeting room 2	94.4	6	0.56	6
Meeting room 3	103.7	6	0.62	6

Internal heat supply

Section called "Persons" describes the heat contribution from people, according to SBI213 in that building for more populated part is 4 W/m^2 but for not that much populated zones like toilets is 1,5. Apparatus depends on how much electronic stuff is in each space. It is divided for 0 W/m^2 or 6 W/m^2 and it is also according to SBI213 directions.

	Internal heat supply	Area (m2)	Persons (W/m2)	App. (W/m2)	App.night (W/m2)
	Zone	544,3	2060,9 W	3193,2 W	0,0 W
1	Toilets	12,1	1,5	0	0
2	Cafeteria	248,3	4	6	0
3	Technic room	34,4	1,5	6	0
4	Meeting rooms	249,5	4	6	0

Lighting

The table presents lighting in the building. All factor are based on SBI213 direction. For General factors we put 2 W/m^2 it means that the light is switch on and 5 W/m^2 as a minimum for lighting conditions in occupied time. Lighting depends of the room if it is big room like cafeteria is 200 lux but for smaller rooms like toilets are 50 lux. DF factor shows 2 if the room has windows and O if not. Control section we divided into A or M, because in toilets and technic room we want to switch light automatically but in the rest of rooms is going to be manually. The rest of factor is taken from SBI213 direction.

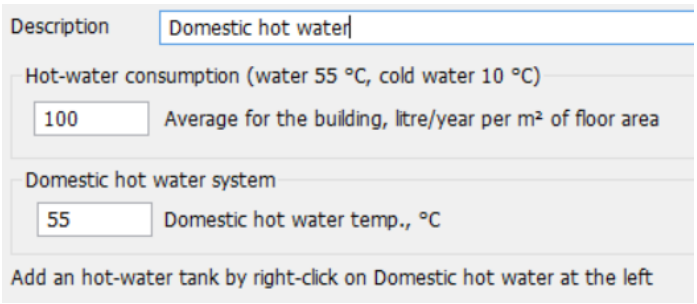
	Lighting	Area (m2)	General (W/m	General (W/m	Lighting (lux)	DF (%)	Control (U, M, A,	Fo (-)	Work (W/m2)	Other (W/m2)	Stand-by (W/n	Night (W/m2)
	Lighting zone	544,3	Min.	Inst.			U,M,A,K					
1	Toilets	12,1	2	5	50	0	A	0,8	0	0	0	0
2	Cafateria	248,3	2	5	200	2	M	1	1	0	0,1	0,1
3	Technic room	34,4	2	5	50	2	A	0,8	0	0	0	0
4	Meeting rooms	249,5	2	5	200	2	M	1	1	0	0,1	0,1

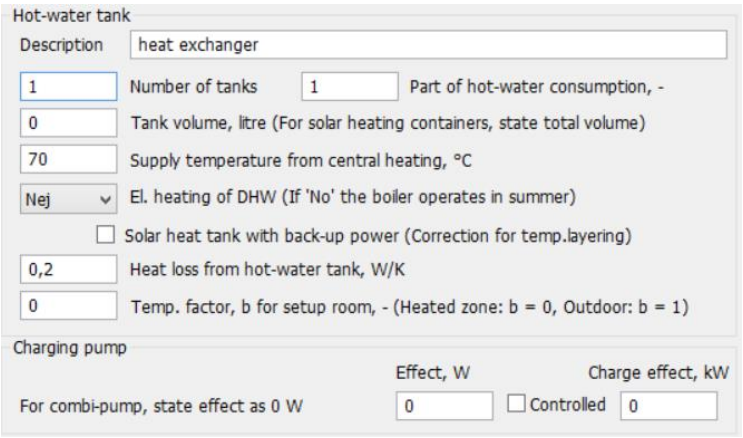
Heat distribution plant

In the building we decided for district heating and radiators, we do not have floor heating.

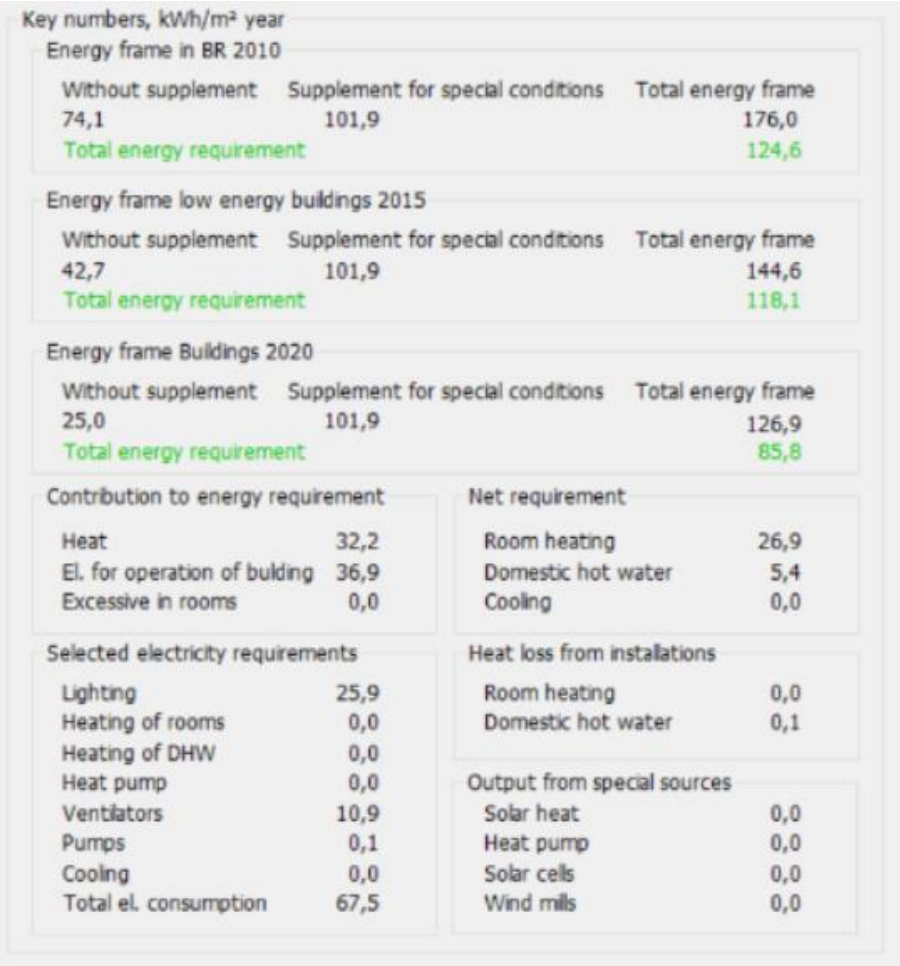
Domestic hot water

Normally domestic hot water is heated up to 55 degrees. And average in other building is about 100 L/m^2. We decided not to use a pump circulation to get hot water in a pipe immediately (because distance from technic room to the kitchen is really big.). Instead of that, we decided to wait few seconds (around 20 seconds) for hot water and save some money.





Result of the energy frame



Key numbers, kWh/m² year

Energy frame in BR 2010

Without supplement	Supplement for special conditions	Total energy frame
74,1	101,9	176,0
Total energy requirement		124,6

Energy frame low energy buildings 2015

Without supplement	Supplement for special conditions	Total energy frame
42,7	101,9	144,6
Total energy requirement		118,1

Energy frame Buildings 2020

Without supplement	Supplement for special conditions	Total energy frame
25,0	101,9	126,9
Total energy requirement		85,8

Contribution to energy requirement

Heat	32,2
El. for operation of bulding	36,9
Excessive in rooms	0,0

Net requirement

Room heating	26,9
Domestic hot water	5,4
Cooling	0,0

Selected electricity requirements

Lighting	25,9
Heating of rooms	0,0
Heating of DHW	0,0
Heat pump	0,0
Ventilators	10,9
Pumps	0,1
Cooling	0,0
Total el. consumption	67,5

Heat loss from installations

Room heating	0,0
Domestic hot water	0,1

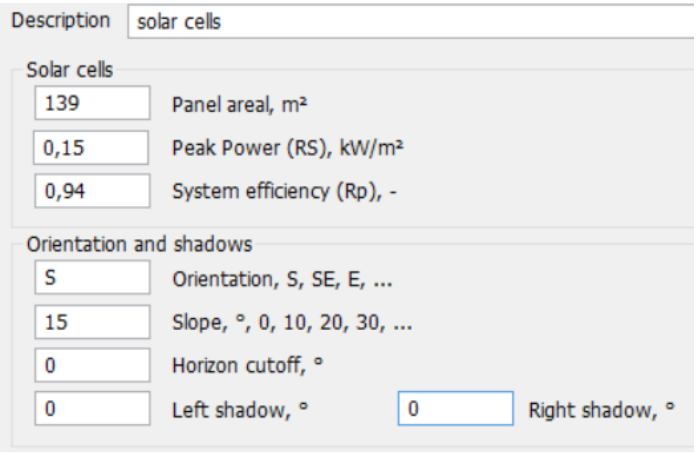
Output from special sources

Solar heat	0,0
Heat pump	0,0
Solar cells	0,0
Wind mills	0,0

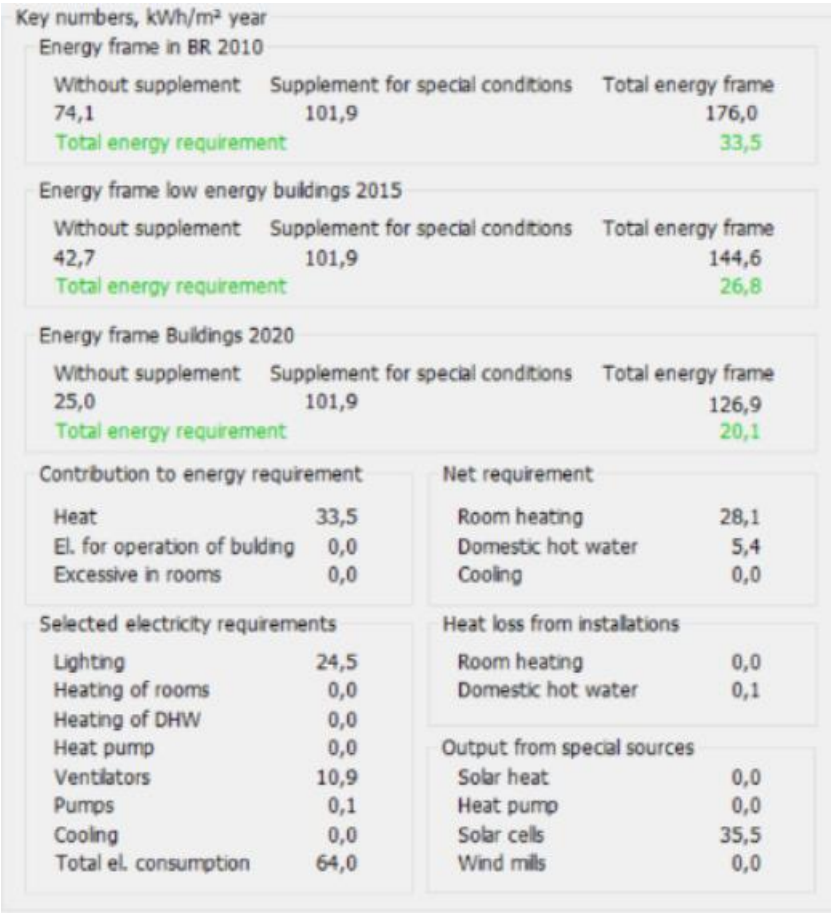
Conclusion

That result shows that the building fulfills the building regulations demand from 2010, 2015 and also 2020 year. This effect of energy frame is without solar cells. But we want to reduce electricity operation of the building to “0” because it is going to cost too much and we decided to put solar cells on the southern part of the cafeteria roof with the slope 15 degrees. After calculations we know that is needed 139 m^2 of solar cells.

Solar cells



The final result with solar cells



Appendix

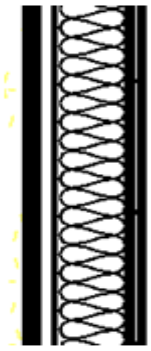
U-value external walls

Construction Architect

Form for calculations of u-values (transmission coefficient) after DS418, Edition 6.

1. Heat flow direction:
   - ■ Horizontal (wall) ⇒ R_{si} = 0,13 and R_{se} = 0,04
   - ☐ Upwards (Roof) ⇒ R_{si} = 0,10 and R_{se} = 0,04
   - ☐ Downwards (floor) ⇒ R_{si} = 0,17 and R_{se} = 0,04 at constructions direct against soil,
     Ex. Ground supported floor is R_{se} replaced by R_n, look at DS418 table 6.9

2. Calculation of the uncorrected transmittal coefficient U'

Construction:	Materiale layer	d [m]	λ_{design} [W/mK]	R [m²K/W]
	Rsi (ventilated cavity)			0,13
	Studs(with insulation in between)	0,18	0,049	3,67
	Battens (with insulation in between)	0,038	0,038	1
	OSB board	0,012	0,45	0,026
	Gypsum	0,012	0,25	0,048
	Rsi			0,13
			$\Sigma R1_{layer}$	5,004
			U'1 [W/m²K]	0,19

3. Determination of corrections

Correction for air gabs in the construction ΔU_g, look at DS418 A.2

- ■ Level 0 ⇒ ΔU'' = 0,00
- ☐ Level 1 ⇒ ΔU'' = 0,01
- ☐ Level 2 ⇒ ΔU'' = 0,04

$$\Delta U_g = \Delta U'' \left(\frac{R_{layer}}{\Sigma R_{layer}} \right)^2 \quad \Delta U_g = 0{,}00 =$$

Correction for ties ΔU_t, look DS418 table A.3.2

Type of tie_____ Diameter_____ Thickness of insulation _____

Number of ties pr. m²: ☐ 4 ties pr. m² ☐ 8 ties pr. m²

Read ΔU_t _____

4. Calculation of the corrected transmissions coefficient U

$U = U' + \Delta U_g$ = 0,19

23-10-14

- Studst (with insulation between) = 0,049 was calculate by using formula:

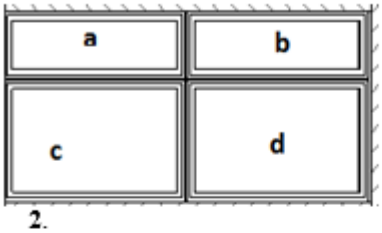
  $\Lambda' = \lambda_{wood} * L_{wood} + \lambda_{insulation} * l_{insulation} / l_{c/c}$

Surface of external wall:

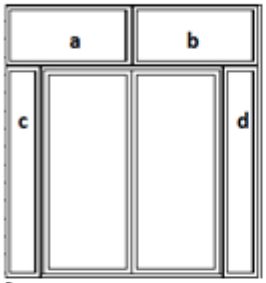
(65,4+15+2,10+26,34+6,63+26,31+8,96+14,85)*4,4=165,59*4,4=728,60 [m2]

Windows:

1.



2.



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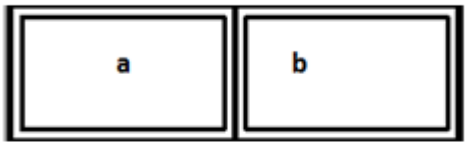

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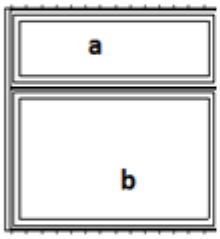

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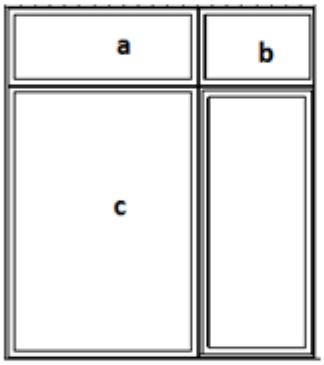

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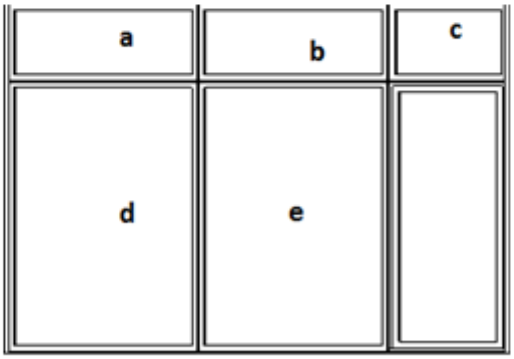
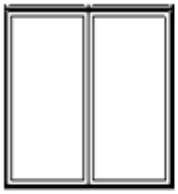


6.

Doors:

1. 

2. 

Orientation	Window	Number of it	Surroundings
West+east	1) 1,608*0,428=0,69	8	(1,780*0,600)-0,69=0,39
	∑=8*0,69=5,52		∑=8*0,39=3,12
South	2)a: 1,45*0,428=0,62 b: 0,62 c:1,45*0,916=1,33 d:1,33 a+b+c+d=3,9 ∑:2*3,9=7,8	2	3,23*1,700=5,5 5,50-3,9=1,6 ∑:1,6*2=3,2
	3) a:1,15*0,498=0,57 b:0,57 c:0,25*1,986=0,51 d:0,51 a+b+c+d:2,16 ∑:2*2,16=4,32	2	ab: 2,49*0,612=1,53 cd: 0,35*2,100=0,73 0,73*2=1,47 1,47+1,53=3 3-2,16=0,84 ∑: 2*0,84=1,68

Orientation	Window	Number of it	Surroundings
	4)a:0,88*0,49=0,43 b: 0,43 a+b: 0,86 ∑:0,86	1	0,612*1,98=1,21 1,21-0,83=0,35 ∑:0,35
	5) a:1,45*0,428=0,62 b:1,45*0,916=1,32 a+b: 1,94 ∑:1,94*2=3,88	2	1,61*1,7=2,73 2,73-1,94=0,79 ∑:1,58
	6) a: 1,39*0,498=0,67 b:0,67 c:0,81*0,498=0,40 d:1,36*1,986=2,7 e:2,7 a+b+c+d+e: 7,14 ∑:7,14	1	A:b:c 3,83*0,612=2,34 D:e 2,93*2,10=6,15 A+b+c+d+e: 8,49 8,49-7,14=1,35 ∑:1,35
	7) a:1,36*0,498=0,68 B:0,81*0,498=0,40 C:1,36*1,986=2,70 A+b+c: 3,78 ∑:3,78*3=11,34	3	A:b2,37*0,612=1,45 C:1,48*2,100=3,1 A+b+c:4,55 4,55-3,78=0,77 ∑:0,77*3=2,31

Doors:

Orientation	Door	Number of it	Surroundings
South	1) 0,76*1,916=1,45 1,45*2=2,9 ∑:2,9*3=8,7	3	1,78*2,046=3,64 3,64-2,9=0,74 ∑:0,74*3=2,22
	0,74*1,916=1,41 ∑:1,41*3=4,23	3	0,89*2,046=1,82 1,82-1,41=0,41 ∑:0,41*3=1,23

A2: 3,12+3,2+1,68+0,35+1,58+1,35+2,31+2,22+1,23=17,04
728,60-17,04=711,56 (**A1**)

Perimeter windows:
1) (2*1,780+2*0,600)*8=(3,56+1,2)*8=4,76*8=38,08
2) (2*5,5+2*1,6)*2=(11+3,2)*2=14,2*2=28,4
3) (2*2,49+2*0,612+4*2,100+2*0,35)*2=(4,98+1,22+8,4+0,7)*2=15,3*2=30,6
4)(2*0,612+2*1,98)=(1,22+ 3,96)=5,18
5)(2*1,61+2*1,7)*2=(3,22+3,4)*2=6,62*2=13,24
6)(2*3,83+2*0,612+2*2,100+2,93)=(7,66+1,22+4,2+2,93)=16
7)(2*2,37+2*0,612+2*2,100+1,48)*3=(4,74+1,22+4,2+1,48)*3=11,64*3=34,92

Perimeter doors:
1)(1,78+(2*2,046)*3=(1,78+4,09)*3=5,87*3=17,61
2) (0,89+(2*2,046)*3=(0,89+4,09)*3=4,98*3=14,94

Lk=198,97 [m]

Ψ_k=0,01 (table 6.7.1)

$U' = A_1 * U_1 + Lk * \Psi_k / A_1 + A_2$

U'=(711,56*0,19)+198,97*0,01/728,60=135,19+1,987/728,6=0,18 **W/m²K]**

Final U-value: $U = U' + \Delta U$

Final U-value: U = 0,18 [W/m²K]

Note:

Ψ_k – it shouldn't be added to calculations because it is wood wall with studs, so there is no cold bridges (normally Ψ_k will make the u-value bigger).

The final u-valuse should be 0.19 [W/m²K]

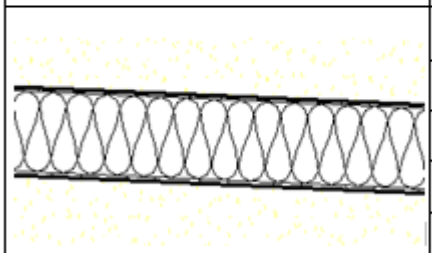
U-value roof

Construction Architect

Form for calculations of u-values (transmission coefficient) after DS418, Edition 6.

1. Heat flow direction:
   - ☐ Horizontal (wall) ⇒ R_{si} = 0,13 and R_{se} = 0,04
   - ■ Upwards (Roof) ⇒ R_{si} = 0,10 and R_{se} = 0,04
   - ☐ Downwards (floor) ⇒ R_{si} = 0,17 and R_{se} = 0,04 at constructions direct against soil,
     Ex. Ground supported floor is R_{se} replaced by R_g look at DS418 table 6.9

2. Calculation of the uncorrected transmittal coefficient U'

Construction:	Materiale layer	d [m]	λ_{design} [W/mK]	R [m²K/W]
	Rse			0.04
	Bitumen felt	0.010	0.050	0.2
	Chipboard	0.012	0.180	0.07
	Beams + Insulation	0.465	0.04	11.63
	Hydrodiode DPM			
	Troltex	0.025	0.072	0.347
	Rsi			0.10
			ΣR_{layer}	12.387
			U' [W/m²K]	0.080

3. Determination of corrections

Correction for air gabs in the construction ΔU_g look at DS418 A.2

- ☐ Level 0 ⇒ ΔU'' = 0,00
- ■ Level 1 ⇒ ΔU'' = 0,01
- ☐ Level 2 ⇒ ΔU'' = 0,04

$$\Delta U_g = \Delta U'' \left(\frac{R_{beam}}{\Sigma R_{layer}} \right)^2 \qquad \Delta U_g = 0.01 \cdot \left(\frac{11.63}{12.387} \right)^2$$

Correction for ties ΔU_f look DS418 table A.3.2

Type of tie_____ Diameter_____ Thickness of insulation _____

Number of ties pr. m²: ☐ 4 ties pr. m² ☐ 8 ties pr. m²

Read ΔU_f _____

4. Calculation of the corrected transmissions coefficient U

$U = U' + \Delta U_g + \Delta U_f$ = __0.08+0.008_____ = 0.09

- Beams (with insulation between) = 0,04 was calculate by using formula:

  $\Lambda' = \lambda_{beam} * L_{beam} + \lambda_{insulation} * l_{insulation} / l_{c/c}$

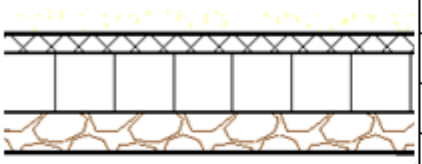
U-value floor

Construction Architect

Form for calculations of u-values (transmission coefficient) after DS418, 7th edition
Wooden floor

1. Heat flow direction:
   - ☐ Horizontal (wall) ⇒ R_{si} = 0,13 and R_{se} = 0,04
   - ☐ Upwards (Roof) ⇒ R_{si} = 0,10 and R_{se} = 0,04
   - ■ Downwards (floor) ⇒ R_{si} = 0,17 and R_{se} = 0,04 at constructions direct against soil,
     Ex. Ground supported floor is R_{se} replaced by R_g, look at DS418 table 6.9.1

2. Calculation of the uncorrected transmittal coefficient U'

Construction:	Materiale layer	d [m]	λ_{design} [W/mK]	R [m²K/W]
	R_{si}			0,17
	Tiles	0,015	2,44	0,006
	Reinforced concrete	0,1	2,44	0,04
	Polystyrene	0,3	0,036	8,3
	Capillary breaking layer	0,125	0,08	1,56
	Capillary breaking layer	0,075	0,08*1,2= 0,096	0,78
	R_g			1,5
			ΣR_{1layer}	12,356
			U_1' [W/m²K]	0,081

3. Determination of corrections

Correction for air gabs in the construction ΔU_g, look at DS418 A.2

- ■ Level 0 ⇒ ΔU" = 0,00
- ☐ Level 1 ⇒ ΔU" = 0,01
- ☐ Level 2 ⇒ ΔU" = 0,04

$$\Delta U_g = \Delta U'' \cdot \left(\frac{R_{insulation}}{\Sigma R_{layer}} \right)^2$$

ΔU_g = 0,00

Correction for ties ΔU_r look DS418 table A.2

Type of tie_____ Diameter_____ Thickness of insulation _____

Number of ties pr. m²: ☐ 4 ties pr. m² ☐ 8 ties pr. m²

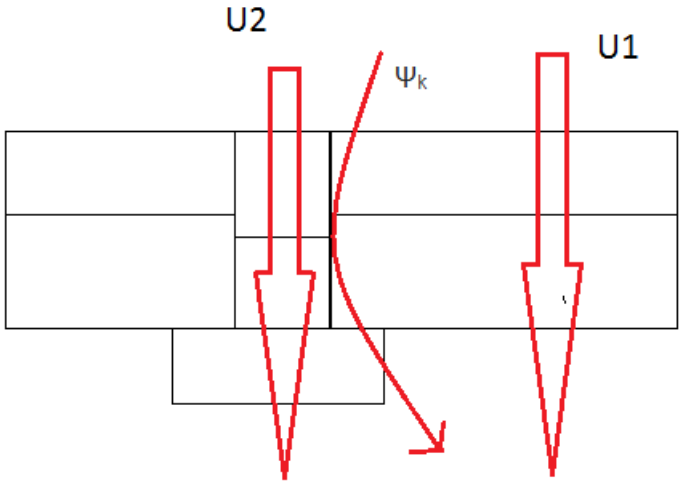
Read ΔU_r _____

4. Calculation of the corrected transmissions coefficient U

U = U' + ΔU_g = 0,1 + 0,03 = 0,13 [W/m²K]

23-10-14

Internal foundations are the part of u-value for the floor because between floor and foundation is break of insulation. To calculate this we use formula $U'=A_1*U_1 +A_2*U_2 + \Psi_k*l / A_1+A_2$



Linear loss

Table 6.12.2 – The joint around windows and doors in insulated timber frame walls with lighweight cladding or with brick work front wall

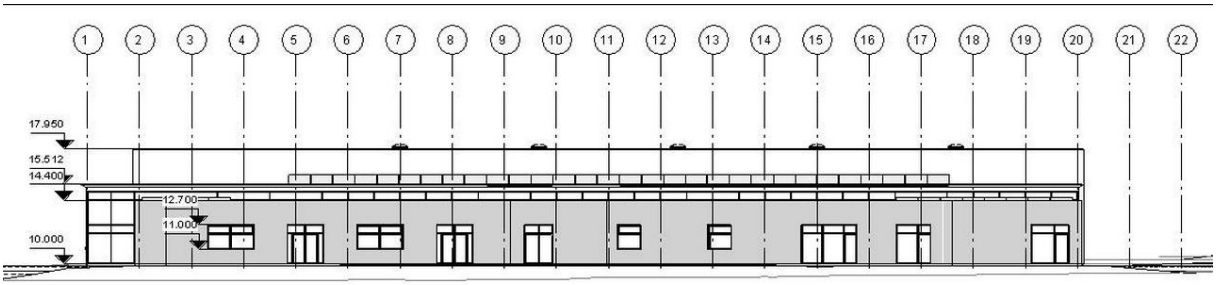
Placement of frame	W/mK	
In line with the insulation	(0,00)	not shown in sketch
60 mm overlapping to the insulation	0,03	see sketch 7 below
20 mm overlapping	0,08	see sketch 8 below
Displaced form the insulation	Values in table 6.12.1b for for "no" cold bridge interruption	see sketch 9 below

Table 6.13.4c - The linear loss ψ_f in W/mK for foundations at terrain deck, where the concrete plate with knob is casted into the foundation (see figure 6.13.5)

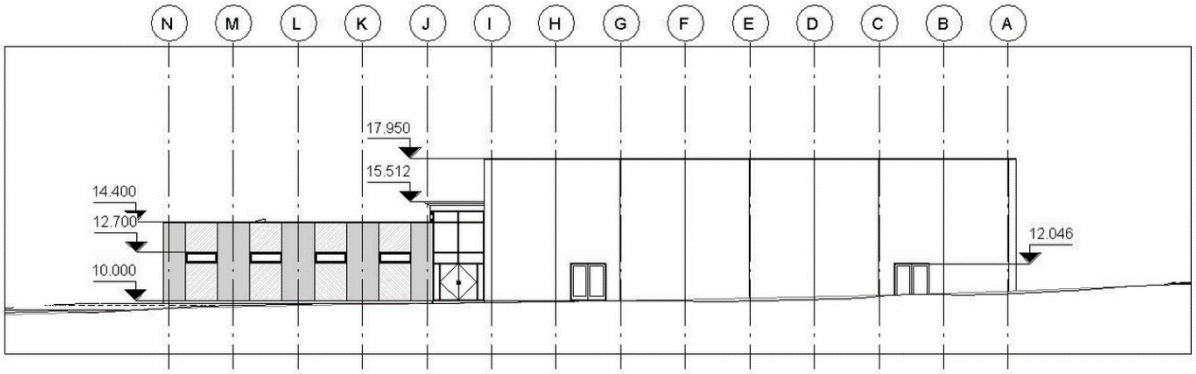
Rear wall		Light weight concrete, brick or concrete			Light weight concrete		Concrete	
Foundation	Insulation above concrete plate:	None			75 mm		75 mm	
	U-value for terrain deck:	0,30	0,20	0,10	0,20	0,10	0,20	0,10
Light clinker concrete upper 40 cm[1)2)]		0,29	0,21	0,17	0,15	0,12	0,22	0,16
Light clinker concrete upper 60 cm[1)3)]		0,25	0,18	0,14	0,14	0,11	0,20	0,14

[1)] Light clinker concrete with thermal conductivity of 0,25 W/mK and width on 39 cm.
[2)] Central insulation (150 mm) in both courses with thermal conductivity at most 0,04 W/mK.
[3)] Central insulation (150 mm) in upper 40 cm with thermal conductivity at most 0,04 W/mK.

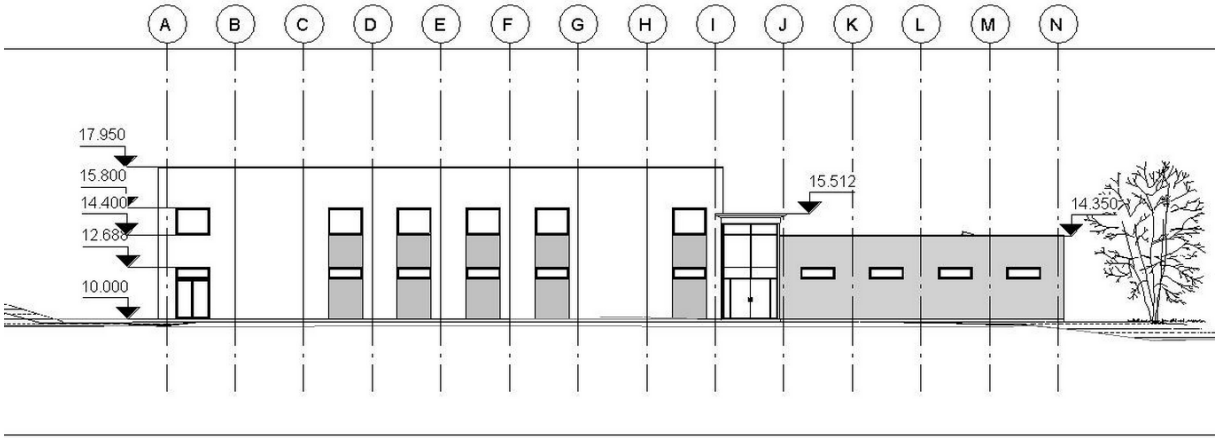
Drawings



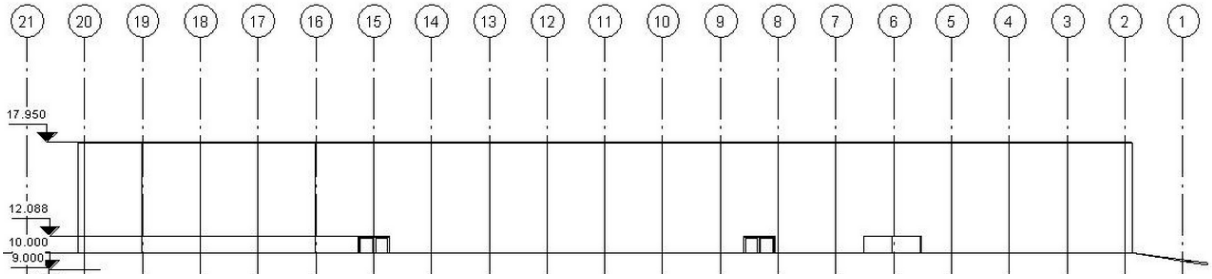
South elevation



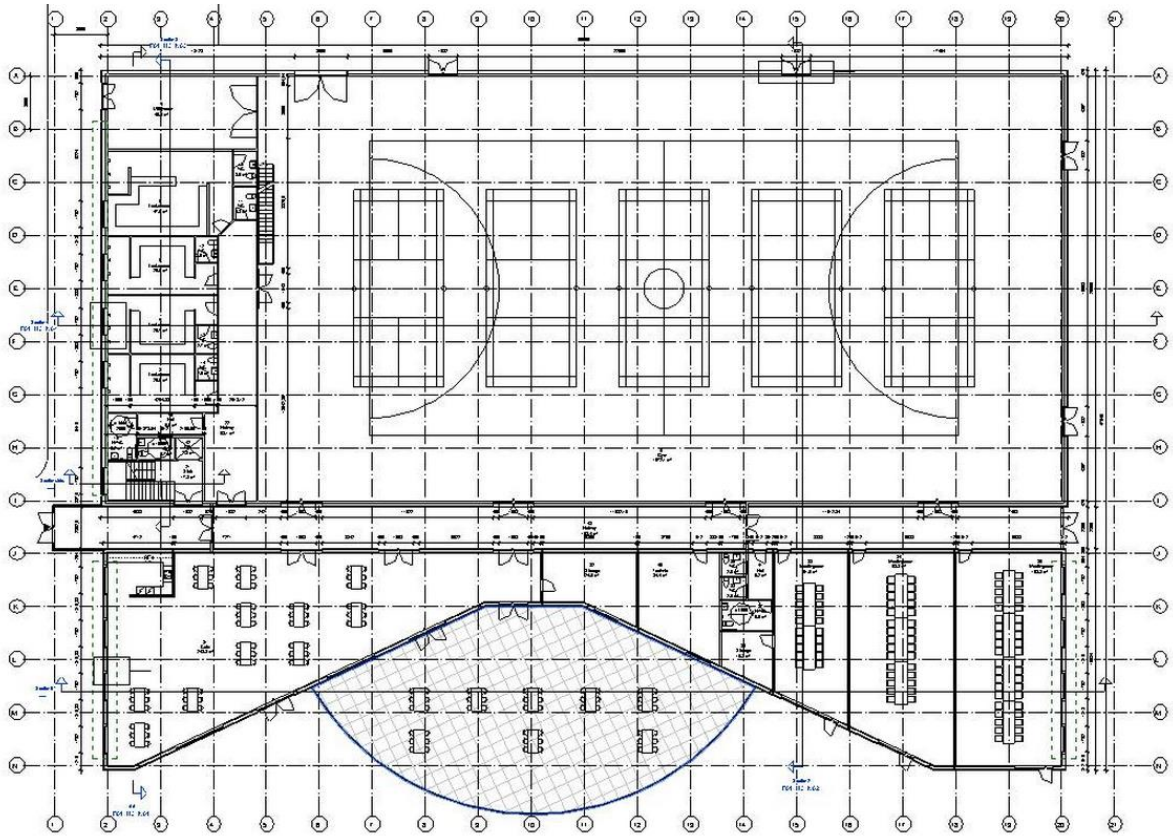
West elevation



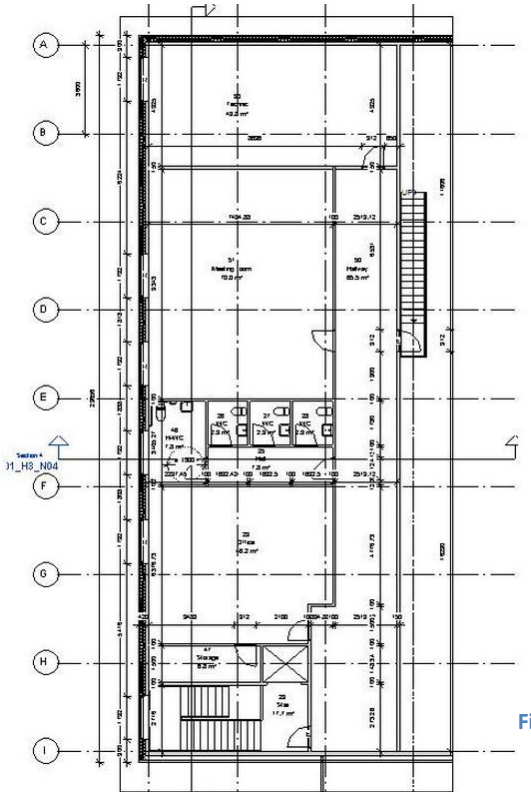
East elevation



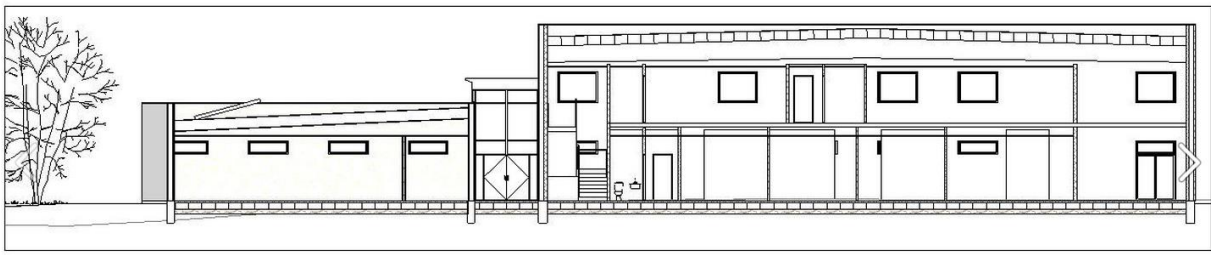
North elevation

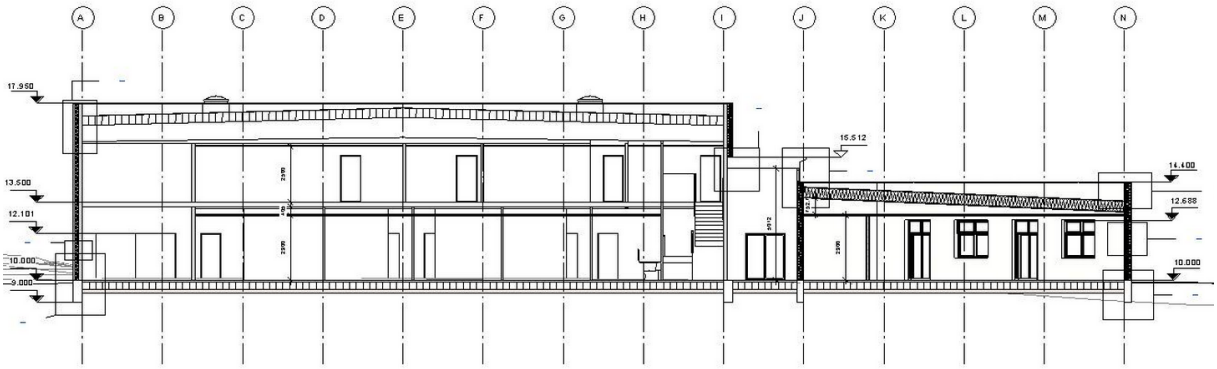


Ground floor



First floor




A
B
C
D
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G
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J
K
L
M
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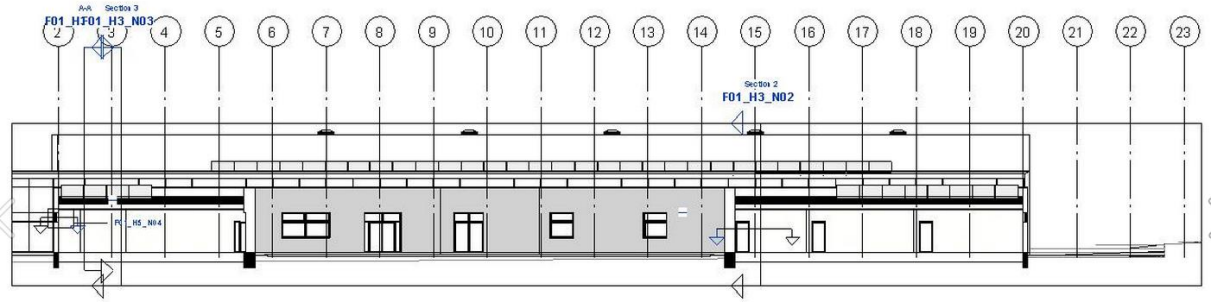
17.950
13.500
12.101
10.000
9.000
16.512
14.400
12.688
10.000


A-A Section 3
F01_HF01_H3_N03
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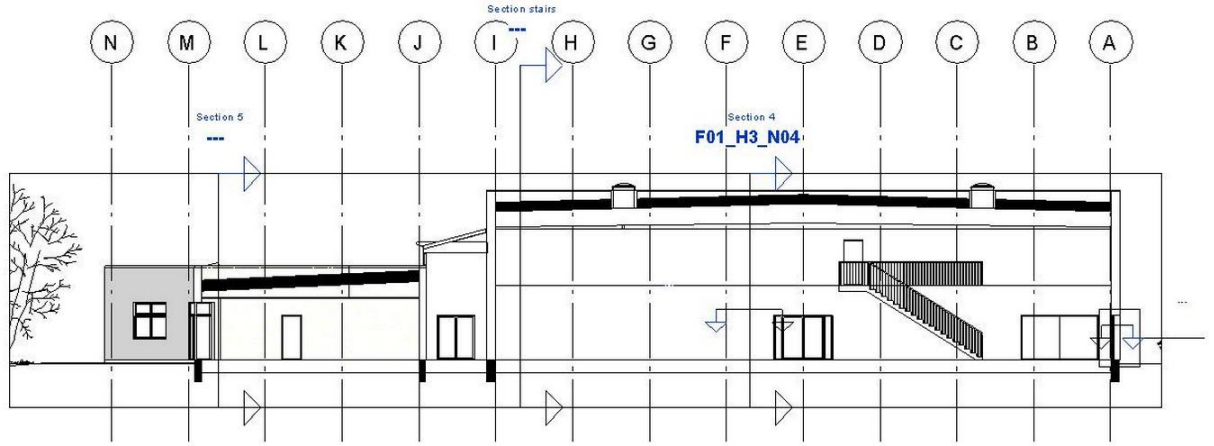
23
Section 2
F01_H3_N02


Section stairs

N
M
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K
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G
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E
D
C
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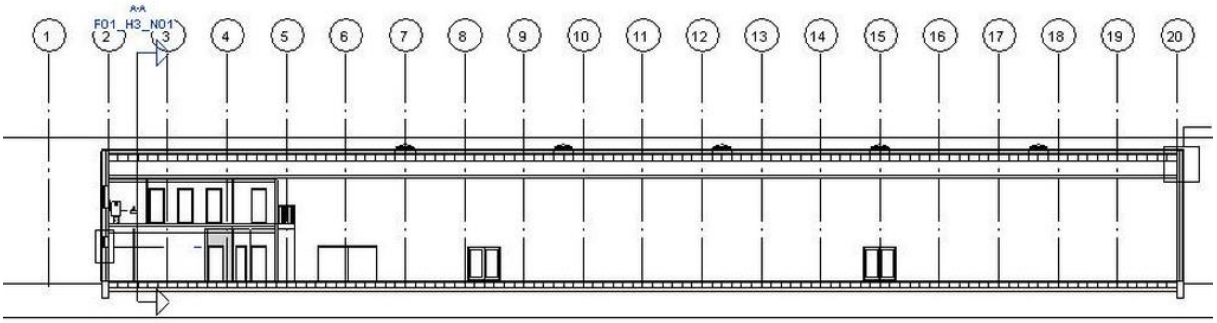
A
Section 5

Section 4
F01_H3_N04


A-A
F01_H3_N01
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