BYENS SKOLE

"A SCHOOL FOR THE FUTURE"

PRESENTATION APPENDIX

Master Thesis 2020
Sustainable Architecture
Aalborg University

APPENDIX 1

Calculation of ventilation rates per zone per plant. To calculate the needed ventilation rate in the different zones, the following formula has been used:

$$q_{tot} = n_{child}\ q_{p.child} + n_{adult}\ q_{p.adult} + A\ \ q_B$$

n_{child} = number of children
$q_{p.child}$ = outdoor air supplied per child (3 l/s*)
n_{adult} = number of adults
$q_{p.adult}$ = outdoor air supplied per adult (5 l/s*)
A = floor area (m^2)
q_B = outdoor air supplied per squaremeter (0.35 l/s per m^{2*})

https://bygningsreglementet.dk/Tekniske-bestemmelser/22/Krav/447#78aac1fc-ea64-41eb-888f-b9f6dba9eaac

APPENDIX 2

Calculation of ventilation rates per zone per plant.

PLANT 1				
Zone	Area (0.35 l/s per sqm)	Number of children (3 l/s per child)	Number of adults (5 l/s per adult)	Max. Ventilation rate (m3/h)
0.-6. grade	1696	392	30	6910.56
SFO 2	470	90	10	1744.2
Total				8654.76
PLANT 2				
Zone	Area (0.35 l/s per sqm)	Number of children (3 l/s per child)	Number of adults (5 l/s per adult)	Max. Ventilation rate (m3/h)
7.-9. grade	743	170	15	3042.18
Administration/teachers office	900	0	100	2934
Knowledge about food	110	30	2	498.6
CKR	870	50	20	1996.2
Library	230	55	4	955.8
Common area	447	80	6	1535.22
Kitchen	140	0	10	3440.88
Total				14402.88
PLANT 3				
Zone	Area (1.5 l/s per sqm)	Number of children (3 l/s per child)	Number of adults (5 l/s per adult)	Max. Ventilation rate (m3/h)
Craft zone	577	90	4	4159.8
PLANT 4				
Zone	Area (1.0 l/s per sqm)	Number of children (3 l/s per child)	Number of adults (5 l/s per adult)	Max. Ventilation rate (m3/h)
Science zone	568	120	4	3412.8
Total:				30630.24

APPENDIX 3

Calculation of solar panels.

Step 1: Total energy consumption.
Total energy consumption for building service (ventilation and lightning) and equitment (from BE18): 300.000 kWh /year

Step 2: Amount of solar panels with an integrated optimal plant.
System efficiency (m^2) =
Total energy (kWh) / (evaluation of system factor * solar radiation intensity (kWh/m^2))

300.000 kWh / (0,8 * 999 kWh/m^2) = 375 m^2

Amount of solar panels with a module efficiency of 12 %:
(375 m^2 * 100) / 12 = 3125 m^2

Step 3: Calculation of the energy that 340 m^2 with an integrated less optimal plant (light shadow), would be able to produce.
71,928 kWh/m^2 * 340 m^2 = 24.446 kWh

Step 4: Amount of solar panels with an integrated optimal plant.
Energy: 300.000 kWh - 24.446 kWh = 275.554 kWh

System efficieny: 275.554 kWh / (0,8 * 999 kWh/m^2) = 307 m^2

Amount of solar panels with a module efficiency of 12 %:
(307 m^2 * 100) / 12 = 2558 m^2

Step 5: Total amount of solar panels.
2558m^2 + 340 m^2 = 2900 m^2

Technical specification for the calculation of the amount of solar panels.

Module efficiency (%)	Standard	Highefficieny
Monocrystalline	15	18
Polycrystalline	12	15
Amorft / thinfilm (tsmc solar)	6	12

Evaluation of system factor	Free-standing	Intergrated
Optimal plant with highefficient inverte	0,85	0,8
Average plant with standard inverter	0,75	0,7
Less optimal plant, fx light shadow	0,65	0,6

Solar radiation intensity (kWh/m2)	EAST	SOUTH	WEST
45 degree	914	1163	901
90 degree (facade)	671	892	662
0 degree	999	999	999
15 degree	988	1097	981
30 degree	958	1152	947

APPENDIX 4

U-value hand calculation. With hand calculation, the U-value for the wall construction is calculated. The wall consists five layers, that are a part of the climate screen, because the gap behind the cladding is ventilated and not insulating.
Two of these five layers are inhomogeneous layers. This concerns the installation layer, consisting of insulation and battens. The other layer is the insulation layer consisting of insulation and I-profiles that keep the layers connected. In the two inhomogeneous layers the thermal conductivity is calculated as an average, based on each materials share of the wall.
The U-value is wished for the wall to be maximum 0,09 W/m²K, and the thickness of the insulation layer is ajusted to this. The insulation layer is therefor 365 mm.

U-value calculation in Ubakus. The U-values for the wall is checked up in the calculation tool Ubakus.
The roof and the foundation are wished to have an U-value at maximum 0,08 W/m²K, and the the construction of the envelopes are designed to perform that.

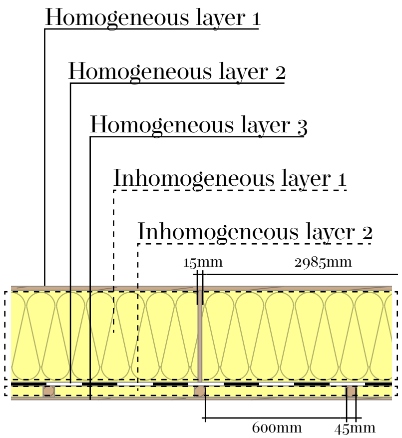
Homogeneous layer 1:
Wind barrier, 10 mm, 0,13 W/mK

Homogeneous layer 2:
Vapour barrier, 0,5 mm, 0,22 W/mK

Homogeneous layer 3:
Plywood, 15 mm, 0,13 W/mK

Inhomogeneous layer 1, insulation:
Insulation, 365 mm, 0,037 W/mK
I-profiles, 365 mm, 0,13 W/mK

Inhomogeneous layer 2, installation:
Insulation, 45 mm, 0,037 W/mK
Battens, 45 mm, 0,13 W/mK



$$U = \frac{1}{R_{si} + \sum R_h + \sum R_{inh} + R_{se}}$$

$$R_h = \frac{d_h}{\lambda_h}$$

$$R_{inh} = \frac{d_{inh}}{\lambda_{inh}}$$

$$\lambda_{inh} = \frac{A_a\lambda_a + A_b\lambda_b}{A_a + A_b}$$

$$\lambda_{inh1} = \frac{A_{a1}\lambda_{a1} + A_{b1}\lambda_{b1}}{A_{a1} + A_{b1}} = \frac{0{,}015m * 0{,}13\frac{W}{mK} + 2{,}985m * 0{,}037\frac{W}{mK}}{0{,}015m + 2{,}985m} = 0{,}0375\frac{W}{mK}$$

$$R_{inh1} = \frac{d_{inh1}}{\lambda_{inh1}} = \frac{0{,}0375\frac{W}{mK}}{0{,}365m} = 9{,}7424\frac{m^2K}{W}$$

$$\lambda_{inh2} = \frac{A_{a2}\lambda_{a2} + A_{b2}\lambda_{b2}}{A_{a2} + A_{b2}} = \frac{0{,}045m * 0{,}13\frac{W}{mK} + 0{,}555m * 0{,}037\frac{W}{mK}}{0{,}045m + 0{,}555m} = 0{,}0440\frac{W}{mK}$$

$$R_{inh2} = \frac{d_{inh2}}{\lambda_{inh2}} = \frac{0{,}044\frac{W}{mK}}{0{,}045m} = 1{,}0233\frac{m^2K}{W}$$

$$R_{h1} = \frac{d_{h1}}{\lambda_{h1}} = \frac{0{,}01m}{0{,}13\frac{W}{mK}} = 0{,}0769\frac{m^2K}{W}$$

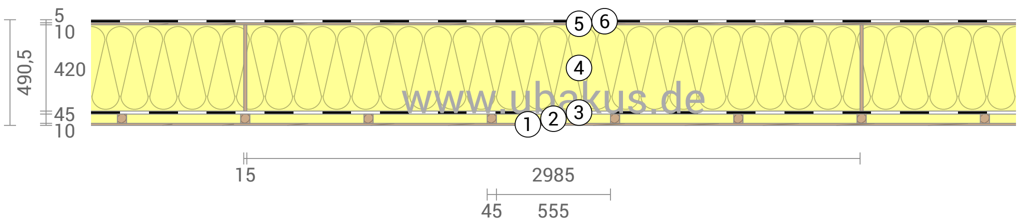
$$R_{h2} = \frac{d_{h2}}{\lambda_{h2}} = \frac{0{,}0005m}{0{,}22\frac{W}{mK}} = 0{,}0023\frac{m^2K}{W}$$

$$R_{h3} = \frac{d_{h3}}{\lambda_{h3}} = \frac{0{,}015m}{0{,}13\frac{W}{mK}} = 0{,}1154\frac{m^2K}{W}$$

$$U = \frac{1}{R_{se} + \sum R_h + \sum R_{inh} + R_{si}}$$

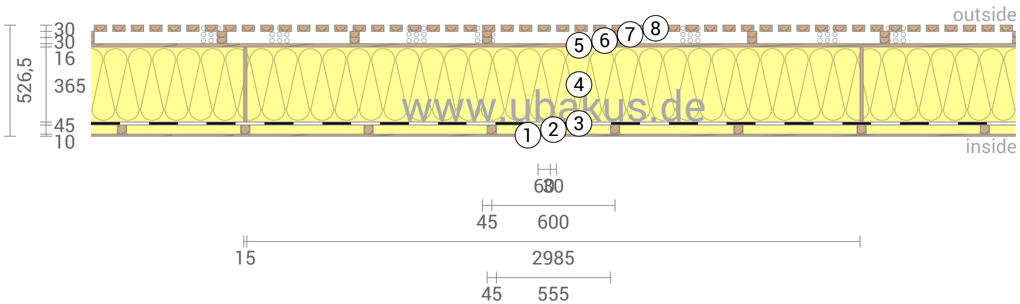
$$= \frac{1}{0{,}04\frac{m^2K}{W} + 0{,}0769\frac{m^2K}{W} + 0{,}0023\frac{m^2K}{W} = 0{,}1154\frac{m^2K}{W} = 9{,}7424\frac{m^2K}{W} + 1{,}0233\frac{m^2K}{W} + 0{,}13\frac{m^2K}{W}} = 0{,}0898\frac{W}{m^2K}$$

Roof construction:
0,08 W/m²K



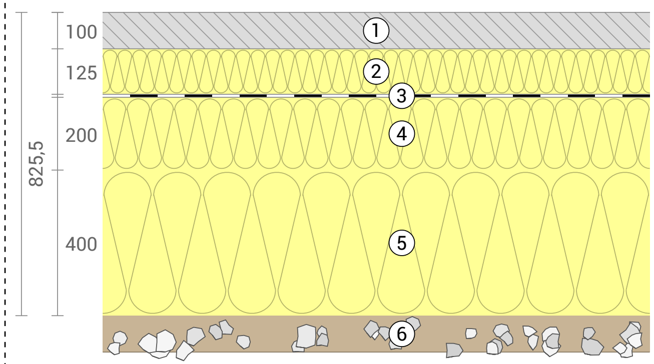
1. Cross Laminated Timber (10 mm)
2. Seegrass (45 mm)
3. Vapor barrier sd=100m
4. Seegrass (420 mm)
5. Cross Laminated Timber (10 mm)
6. Roofing felt

Wall construction:
0,09 W/m²K



1. Cross Laminated Timber (10 mm)
2. Seegrass (45 mm)
3. Vapor retarder sd=10m
4. Seegrass (365 mm)
5. Wind Barrier Cross Laminated Timber (16 mm)
6. Rear ventilated level (30 mm)
7. Rear ventilated level (30 mm)
8. Pine vertical cladding (30x60)

Foundation construction:
0,08 W/m²K

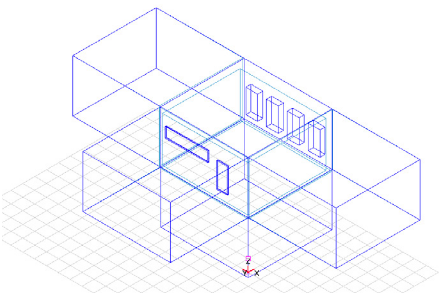


1. Concrete (100 mm)
2. Insulation and underfloor heating (125 mm)
3. Radon barrier
4. Insulation/Polystyrene (200 mm)
5. Sea shells (400 mm)
6. Soil

APPENDIX 5

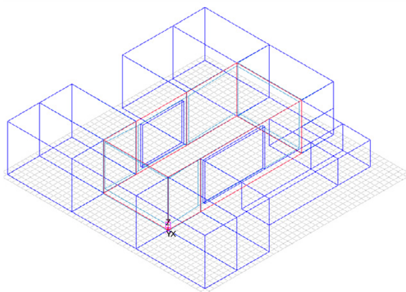
Screenshots from BSim

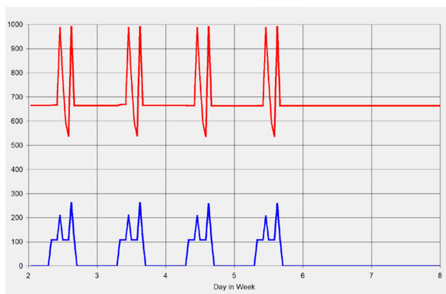
Model 1: Classroom



Undervisnir	Sum/Mean	(365 days)
qHeating	279.36	279.36
qCooling	0.00	0.00
qInfiltration	-497.67	-497.67
qVenting	0.00	0.00
qSunRad	1723.53	1723.53
qPeople	1970.10	1970.10
qEquipment	1405.34	1405.34
qLighting	1864.20	1864.20
qTransmissi	-4187.21	-4187.21
qMixing	0.00	0.00
qVentilation	-2556.38	-2556.38
Sum	1.26	1.26
tOutdoor me	8.1	8.1
tOp mean(°I	22.0	22.0
AirChange(/	0.9	0.9
Rel. Moistui	37.7	37.7
Co2(ppm)	549.5	549.5
PAQ(-)	0.4	0.4
Hours > 21	6632	6632
Hours > 26	11	11
Hours > 27	7	7

Model 2: Common room





Fælles rum	Sum/Mean	(365 days)
qHeating	4607.62	4607.62
qCooling	0.00	0.00
qInfiltration	-340.09	-340.09
qVenting	0.00	0.00
qSunRad	15933.15	15933.15
qPeople	17313.00	17313.00
qEquipment	1234.99	1234.99
qLighting	706.20	706.20
qTransmissi	-30253.99	-30253.99
qMixing	0.00	0.00
qVentilation	-9200.89	-9200.89
Sum	-0.00	-0.00
tOutdoor me	8.1	8.1
tOp mean(°I	19.9	19.9
AirChange(/	0.3	0.3
Rel. Moistui	45.6	45.6
Co2(ppm)	658.6	658.6
PAQ(-)	0.5	0.5
Hours > 21	2723	2723
Hours > 26	10	10
Hours > 27	2	2

APPENDIX 6

Dimensioning of the pipes. The total volume of air for the whole school building is approximately 22000 m^3/t. The biggest volume of air that need to be moved longest, is 4200 m^3/t, equal to 1,2 m^3/s.

Because of the building form, it will be preferred with three ventilation plants, placed strategically due to pressure loss and the length of the pipes. The chosen ventilation plants are two Nilan VPN 1200 Cleanroom, which both can cover volume of air from 3600 m^3/h to 22000 m^3/h and two smaller plants for the craft and science part. Therefore the two main technical rooms needs to be at least 4,5 m x 2,7 m to be able to facilitate the plant and a sufficient service area.

Since The Danish Building Regulations prescribes a maximum noise from pipes in meeting rooms on 30 dB (section 17 - Noise (§ 368 - § 376), table 5.2), this project strives to achieve this noise level in workrooms. Therefore, the air velocity must not exceed 9 m/s in the distribution pipes, in rooms with visible pipes.

The maximum ventilation rate on 1,2 m^3/s, to secure a sufficient indoor environment in one floor of the pre-preparatory classes and the after school care, the maximum dimension of the pipes in the distribution part should be 400 mm, as shown on the pressure loss diagram.

A.27. Tryktabsdiagram for spiralfalsede rør.