Integrated Energy Design

Assignment 1

Group 5:

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Contents

Abstract

In our team, we have considered this report as the way for learning and understanding what is integrated energy design.

The report consists of three main chapters:

1) Project goals

2) Team work process

3) Design process:

   i. Regulations
   ii. Model simulation: original model, modified model

4) Conclusion

1. Introduction

ZE+hytte is an energy efficient house designed for SDE 2012. It is designed as a residential building for two people. The building consists of $64.8m^2$ heated floor area; sunspace (buffer zone) facing south and technical room. And the total area is estimated be approximately $74m^2$.

The analysis task of the project will be analysis by four steps:

- Regulation study
- Setting up energy targets
- Original project analysis
- Simulations for improving the performance
- Analysis of the performance
- Suggestions for follow up

Circulation process

2. Project goals

The house will be designed according to the Norwegian passive house standard. The design of the house should reduce the heating load as much as possible.

3. Team work

The group of three engineering students from the Klimax course and four students from the Integrated energy design course cooperated in order to improve the performance of the building during the conceptual stage of the design process. The cooperation process began with series of discussions during which the concept of the project and its main parameters were introduced in the team.

<u>Team work process:</u>

Energy target → Analysis of the original design (engineer / architect) → Communication (engineer + architect) → Engineer simulation with suggestions → Architects analysis of the model (1) → Engineer energy budget → Architect analysis (2), poor architectural (comfort) design from the architect point view → Engineer suggestions (e.g.: improving building envelope) → Future work (simulation with better performance of building envelope in order to improve both energy performance and architectural quality)

Repeat team working process

4. Design process

4.1 Regulations

** Frame: residential house for 2 person*

Tasks		Requirement	Reference
Thermal Comfort			
RH	(%)	40-60	SD Rules P.33
Temperature	(°C)	19-21	NS 3031
Air flow rate	(m^3/m^2h)	1,2	NS 3031
Indoor environment			
Air quality performance		800 ppm	SDE
Lighting level		500 lux	Standard visual
Internal gains			
Lighting	(W/m^2)	1,3	NS 3700
Equipment	(W/m^2)	1,2	NS 3700
Occupants	(W/m^2)	1,5	NS 3700
Small house average		3,2	NS 3700
Air infiltration			
Infiltration	h^{-1}	0,6	NS 3700
Air leakage at 50 p	h^{-1}	0,6	NS 3700
Heat loss			
Heat loss factor	W/m^2k	0,5-0,6	NS 3700
Power (internal gain)			
Lighting	(W/m^2)	1,3	NS 3700
Equipment	(W/m^2)	2	NS 3700
Hot water	(W/m^2)	3,4	NS 3700
Occupancy			
lighting equipment		16/07/52	NS 3700
Ventilation		24/07/52	NS 3700
Primary requirement of passive house: 15 KWh/m^2 a			
Heating demand in this case: 27 kWh/m^2 a			
Total energy demand			
Delivered energy	kWh/m^2a	79	

Trondheim: 19-21°C

Madrid: 22-24°

Table 1: Regulations from SDE and Norwegian standard

Characteristic	Requirement	Reference
U-value walls	0,15 W/m^2K	NS 3700
U-value floor	0,15 W/m^2K	NS 3700
U-value roof	0,13 W/m^2K	NS 3700
U-value window	0,8 W/m^2K	NS 3700
U-value door	0,8 W/m^2K	NS 3700

Table 2: Insulation requirements

4.2 Original Design

4.2.1 Energy calculation

Heated floor area: 64.8 m^2

Window area: 26.7 m^2

Windows area:42.6 % of heated floor area

Window location: west, east, north, skylights

Buffer zone: sunsapce facing sunsapce facing south (windows)

Comfort boundary:

RH: 40-60%

Comfort temperature: 19-21ºC (Trondheim); 22-24 ºC (Madrid)

Lighting level: 500 lux

Internal gain: 3.2 W/m2

Occupancy: 16/07/52

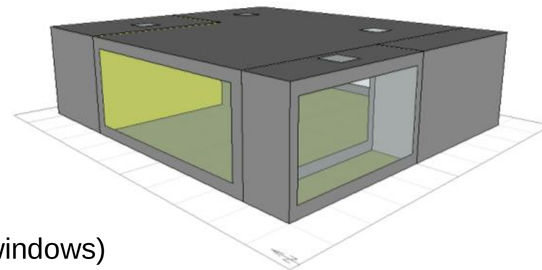


Figure 1: Original model

MONTHLY HEATING/COOLING LOADS

Zone: Living space
Operation: Weekdays 17-08, Weekends 17-08.
Thermostat Settings: 19.0 - 21.0 C

Max Heating: 1859 W at 21:00 on 12th January
Max Cooling: 1217 W at 08:00 on 21st July

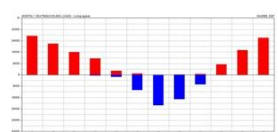
MONTH	HEATING (Wh)	COOLING (Wh)	TOTAL (Wh)
Jan	422767	0	422767
Feb	370346	0	370346
Mar	322132	0	322132
Apr	200705	0	200705
May	76429	0	76429
Jun	25584	27963	53547
Jul	13621	19905	33526
Aug	27330	12902	40231
Sep	91092	892	91983
Oct	189382	0	189382
Nov	312569	0	312569
Dec	383272	0	383272
TOTAL	2435228	61661	2496889
PER M²	37581	952	38532
Floor Area:		64.800 m2	

Figure 2: Trondheim location heating/cooling load

MONTHLY HEATING/COOLING LOADS

Zone: Living space
Operation: Weekdays 17-08, Weekends 17-08.
Thermostat Settings: 22.0 - 24.0 C

Max Heating: 1091 W at 06:00 on 23rd January
Max Cooling: 1755 W at 18:00 on 13th July



MONTH	HEATING (Wh)	COOLING (Wh)	TOTAL (Wh)
Jan	273771	0	273771
Feb	219095	0	219095
Mar	160908	0	160908
Apr	116038	5080	121117
May	28835	14873	43708
Jun	8824	108170	116994
Jul	0	215355	215355
Aug	1730	171447	173177
Sep	4728	68984	73712
Oct	73716	0	73716
Nov	174773	0	174773
Dec	261305	0	261305
TOTAL	1323722	583908	1907630
PER M²	20428	9011	29439
Floor Area:		64.800 m2	

Figure 3: Madrid location heating/cooling load

Heating load in Trondheim is 37.6kWh/m^{2}a. In Madrid, the heating load is 20.4kWh/m^{2}a.

Energibudsjett		
Energipost	Energibehov	Spesifikt energibehov
1a Romoppvarming	1579 kWh	21,1 kWh/m²
1b Ventilasjonsvarme (varmebatterier)	129 kWh	1,7 kWh/m²
2 Varmtvann (tappevann)	3349 kWh	44,7 kWh/m²
3a Vifter	329 kWh	4,4 kWh/m²
3b Pumper	710 kWh	9,5 kWh/m²
4 Belysning	876 kWh	11,7 kWh/m²
5 Teknisk utstyr	1314 kWh	17,5 kWh/m²
6a Romkjøling	10039 kWh	133,9 kWh/m²
6b Ventilasjonskjøling (kjølebatterier)	39 kWh	0,5 kWh/m²
Totalt netto energibehov, sum 1-6	18364 kWh	244,8 kWh/m²

Figure 4: Energy budget for the original solution from Engineer

For heating purpose the engineer get figure of 22.7kWh/m^2 a. Total energy is 244.8kWh/ m^2 a. It is different than the figure architect got.

Mismatch reasons:

- The U-values we have used are different from the ones used by engineers
- Operation schedules are different

4.2.2 Daylight

Average daylight factor 13.2%. Luminance is quite even in side the room, between approx. 200-300lux.

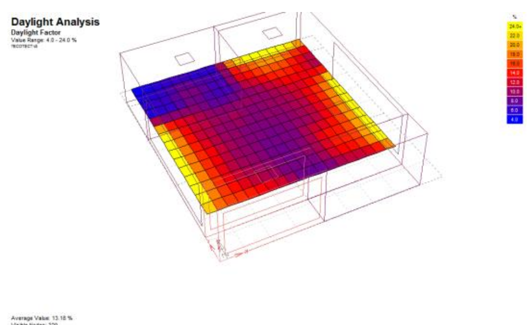


Figure 6: Daylight factor average.

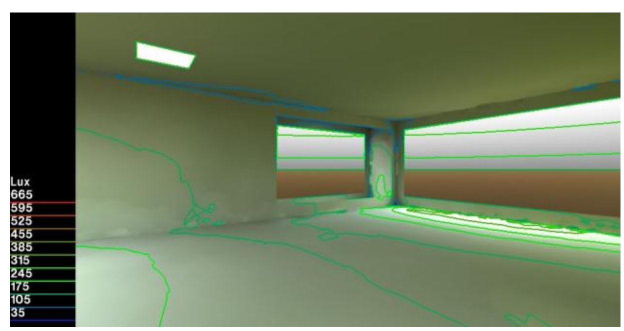


Figure 5: Illuminous (Lux)

We will put focus on optimizing the window size and location design. And in Ecotect, analysis of hourly temperature, the programme could not recognize the south window. So we decided to try the model without sunspace on the south position.

4.3 Modified

4.3.1 Energy calculation

After the analysis of the original model, the engineer suggestion us to reduce the window sizes to 7-15m^2.

Window location: south, west and skylights

Window sizes (12% of heated floor area):

South window: 6.4 m^2; west window: 1 m^2; skylight: 1 m^2.

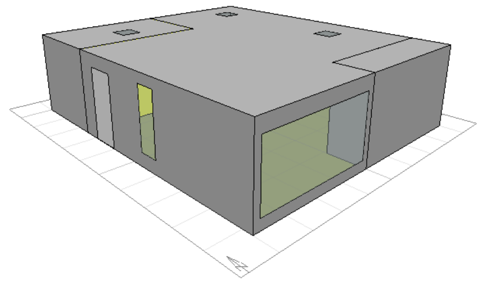


Figure 7: Modified model

Comfort boundary:

RH: 40-60%

Comfort temperature: 19-21ºC (Trondheim); 22-24 ºC (Madrid)

Lighting level: 500 lux

Internal gain: 3.2 W/m2

Occupancy: 16/07/52

MONTHLY HEATING/COOLING LOADS

Zone: Living space
Operation: Weekdays 17-08, Weekends 17-08.
Thermostat Settings: 19.0 - 21.0 C

Max Heating: 1503 W at 21:00 on 12th January
Max Cooling: 740 W at 18:00 on 9th July

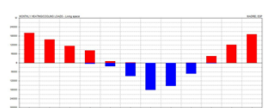
MONTH	HEATING (Wh)	COOLING (Wh)	TOTAL (Wh)
Jan	330776	0	330776
Feb	288548	0	288548
Mar	252226	0	252226
Apr	168372	0	168372
May	64752	0	64752
Jun	22517	20554	43071
Jul	9352	25524	34876
Aug	18246	12174	30420
Sep	65997	1382	67379
Oct	140367	0	140367
Nov	240017	0	240017
Dec	298231	0	298231
TOTAL	1899400	59633	1959034
PER M²	27290	857	28147
Floor Area:		69.600 m2	

Figure 8: Trondheim heating/cooling loads

MONTHLY HEATING/COOLING LOADS

Zone: Living space
Operation: Weekdays 17-08, Weekends 17-08.
Thermostat Settings: 22.0 - 24.0 C

Max Heating: 852 W at 06:00 on 23rd December
Max Cooling: 1201 W at 18:00 on 17th July



MONTH	HEATING (Wh)	COOLING (Wh)	TOTAL (Wh)
Jan	200383	0	200383
Feb	156658	0	156658
Mar	113844	0	113844
Apr	83705	6199	89904
May	10870	24095	34965
Jun	3059	88562	91621
Jul	0	182562	182562
Aug	0	155072	155072
Sep	1027	73314	74341
Oct	45128	2711	47838
Nov	122493	0	122493
Dec	192227	0	192227
TOTAL	929394	532514	1461908
PER M²	13353	7651	21004
Floor Area:		69.600 m2	

Figure 9: Madrid heating/cooling loads

Heating load for Trondheim is 27kWh/m^{2}a. According to the Norwegian passive house standard, we should achieve 27kWh/m^{2}a.

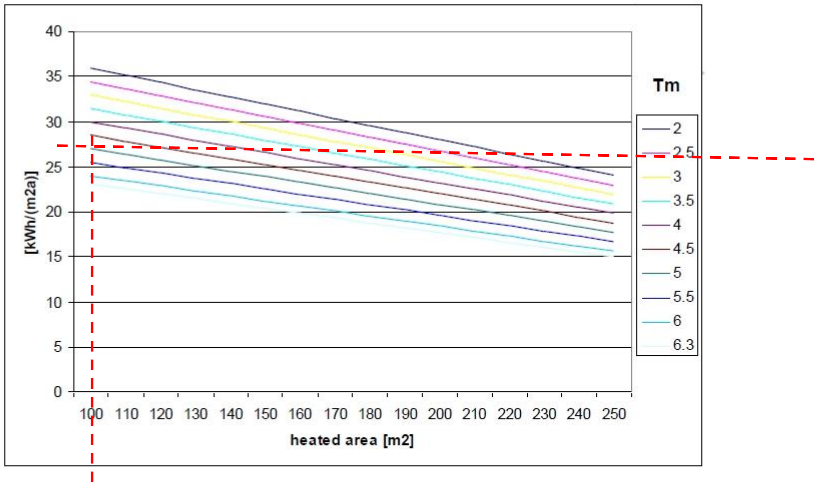


Figure 10: Norwegian passive house requirement

Energibudsjett		
Energipost	Energibehov	Spesifikt energibehov
1a Romoppvarming	570 kWh	7,6 kWh/m²
1b Ventilasjonsvarme (varmebatterier)	99 kWh	1,3 kWh/m²
2 Varmtvann (tappevann)	3349 kWh	44,7 kWh/m²
3a Vifter	329 kWh	4,4 kWh/m²
3b Pumper	187 kWh	2,5 kWh/m²
4 Belysning	876 kWh	11,7 kWh/m²
5 Teknisk utstyr	1314 kWh	17,5 kWh/m²
6a Romkjøling	732 kWh	9,8 kWh/m²
6b Ventilasjonskjøling (kjølebatterier)	39 kWh	0,5 kWh/m²
Totalt netto energibehov, sum 1-6	7495 kWh	99,9 kWh/m²

Figure 11: Energy budget from engineer

In comparison with the data from the engineers , the General difference: Heating/cooling demand. Which is due to the reduction of the window area to 12% of heated floor area. And they also use better U-value in this case:

Wall: 0.12; Roof: 0.08; Floor: 0.08; Windows: 0.5

4.3.2 Daylight

But on the other hand, as can be seen from the analysis the reduction of the glazed area resulted in uneven distribution and low day light levels for both Trondheim and Madrid, with the effect being even more pronounced in Trondheim. This is one of the conflicts between fulfilling energy demand and architectural quality (comfort).

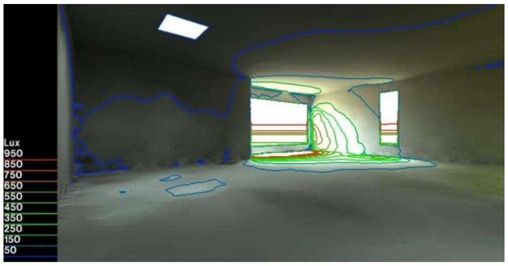


Figure 12: Madrid location luminance

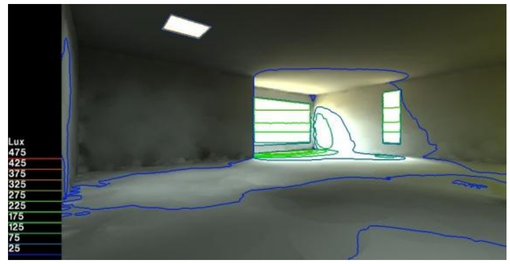


Figure 13: Trondheim location luminance

Possible error:

We also found out that there could be an error during the simulation of the model in Ecotect from the beginning. After we set up the operation schedule, we found out that the during few winter days, when the thermal zone is not in the comfort band, the temperature will be lower than 0°C. We did not take this fact into consideration at the beginning, so the result might be that we have an increased heating load. We think this is the main reason for the mismatch of the heating loads from Ecotect simulation with the engineers calculation.

4.4 Renewable energy supply

The PV-panels covers 50 m^2 of the roof and is assumed to cover the annual electricity demand. The area of the solar collector equals about 5 m^2. When situated in Norway this is estimated to cover two thirds of the draw water, and the value will be even higher when situated in Madrid. Air to water heat pump is chosen to cover the rest.

5. Conclusion

The window size is reduced to 12%. This is done both to satisfy the demand in TEK10, and will strongly affect both the demand for cooling and heating in the building in positive direction.
The U-values is reduced in the roof, floor, walls and windows. This combined with the reduction of window-size nearly eliminates both heating and cooling demand, leaving only about 600 kWh needed for heating. This is a small amount throughout the whole year, and is assumed to be covered by the solar collector on the roof. The small cooling demand is also neglected. A simulation of the building with opened windows shows a cooling demand of zero kWh/year, and therefore tells us that with a user that open the windows when needed don't have use of air condition.
The entire energy consumption of the building over a year is simulated to be about 7495kWh, and with our assumption of use of passive ventilation, solar shading and solar capture, the consumption will be about 4600 kWh.

In order to produce the amount of electricity the cabin is using through the year, it is necessary to install about 46 m^2 solar panels. If we want the cabin to be an Energy+ building, it is recommended to install 50 m^2 solar panels, and 5 m^2 of solar collectors.
Opposed to the Trondheim climate, the Madrid climate will demand more cooling and less heating. However, as climate data on this was unavailable, we have not been able to quantify this.

Further challenges can be looking at actual technical solutions, including distribution systems, demand-regulating technical equipment and lighting. Combining heat sources such as surplus solar heat with the heat pump can create better system efficiencies. Installing transparent solar cells in window shadings can provide more energy.

All this has to be measured against a satisfying indoor climate, which is the sole foundation for living inside a house.