Energy-demand levels and corresponding residential concept houses and the specific challenges of very low-energy houses in colder climates

Deliverable D4 in IEE project NorthPass

Peuhkuri, Ruut Hannele; Tschui, Adrian; Pedersen, Søren

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Energy-demand levels and corresponding residential concept houses and the specific challenges of very low-energy houses in colder climates

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No & name	**D4 Energy-demand levels and corresponding residential concept houses and the specific challenges of very low-energy houses in colder climates**				
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DotA	The work package describes the application of the local criteria of the very low-energy house and other low energy house standards in the participating countries, also those with slightly higher energy demand, and it compares and collects experiences with very low-energy houses, user/market demands and national regulations. The objective of the work package is to provide a basis for the following work packages as to: Which different "concepts" for very low energy houses are known, and what do they imply Task 2 & 3 description: Energy demand of North European very-low energy houses In task 2, the consortium analyses the technical challenges of very low-energy houses in colder climates (e.g. the impact of very low heating demand level, freezing in heat exchangers and ground). The consortium also gathers information on the experiences with very low-energy houses and user/market demands (from task 1 of WP5). Finally, the consortium will define two energy demand levels for very low-energy houses in each participating countries: one level close to the current standards and another level adapted to the regional economic and climate conditions (in cooperation with WP3, this level should be close to the cost-optimal level). Concept houses (by functional demands) In task 3, the consortium provides examples of how the two described energy demand levels (task 2) could be achieved in the different participating countries. Two concepts will be therefore defined per country: one for a detached house and another one for an apartment block. For each of those concepts, the heat and total energy demand will be calculated/simulated using a suitably detailed calculation tool, and the technical solutions (U-values, heat recovery efficiency, air tightness, cooling avoidance technologies, heat distribution systems) will be described.				
Comments					

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1 EXECUTIVE SUMMARY

This deliverable summarizes the remaining work performed in NorthPass Work Package 2, Task 2 and 3. This deliverable provides the *quantitative* comparison of the different regulations and criteria collected and compared *qualitatively* in D2. The analysis in this report is based on comparative calculations with as uniform input as possible for the different calculation tools.

The work reported in this deliverable D4 includes following topics:

- Chapter 3: Comparison of the level of energy requirements of the single countries' building regulations as well as comparison of the level of energy requirements in the different criteria for very low energy buildings. It is concluded that there are very big differences between the energy requirements of the single countries. About a factor 5 between the tightest and loosest regulations. For very low energy building criteria the difference is much smaller.

- Chapter 4: Discussion of the principles of defining "compensating" energy requirements in addition to non-compensating energy requirements and examples of the effect of different impacts. The discussion illustrates that any compensation strategy is bound to be the result of a political discussion. There is no absolute basis for defining the relevant compensations. If the target is to enable the building industry to use the exact same components all over the involved countries, the requirements should rather be defined on component level than on building energy demand

- Chapter 5: Description of the concept buildings. The results of the calculations presented in this report is condensed in the description of the concept buildings – optimised buildings which will meet very tight energy requirements in each of the climates represented.

Some remarks on basic decisions

- As the calculation tool to calculate energy demands and compare different requirements, we have chosen PHPP, as it is based on EN 13790, it is used and known in most of the countries involved, the authors use it every day anyway, and it is built in spread sheets which allows for easy extra programming
- Designing very low energy buildings is multi-faceted, but to keep the communication and comparisons fairly simple, we have chosen to mostly allow only changes to U-values in the calculations performed by the eight partners participating in the work package. This simplified approach does not reflect our general view on very low energy building design!

2 INTRODUCTION

2.1 Purpose and target group

In task 3, the consortium provides examples of how the two described energy demand levels (task 2) could be achieved in the different participating countries. Two concepts will be therefore defined per country: one for a detached house and another one for an apartment block. For each of those concepts, the heat demand and other nationally required characteristics has been calculated using a the appropriate calculation tools, and the technical solutions (U-values, heat recovery efficiency, air tightness, cooling avoidance technologies, heat distribution systems) are described.

The target group of the presented results is professionals and researchers working with very low energy buildings across the involved countries and persons involved in standardisation work and politics related to the building sector as well as the partners in the other WP's of this project.

2.2 Contributions of partners

The representatives from every partner country (Table 1) have performed calculations with relevant calculation tools:

- How do two pre-defined building perform when evaluated with the national calculations tools?
- What does it take to reach the energy requirements of the national buildings code?
- What does it take to reach the energy requirements of any local very low energy building criteria?

The comments to the performed calculations are copied more or less directly from the answers of the respective partners. Passivhus.dk as the WP2 leader is the main contributor of the rest in this D4.

Table 1. Partners involved in WP2

Partner	Task(s) of this partner organisation	Contribution to D2 chapter
Passivhus.dk	WP leader calculations and analysis and reporting	all
Tampere University of Technology	calculations	3
Lund University	calculations	3
SINTEF Building and Infrastructure	calculations	3
National Energy Conservation Agency	calculations	3
University of Tartu	calculations	3
Vilnius Gediminas Technical University	calculations	3
Riga Technical University	calculations	3

2.3 Role within the project

There are 3 deliverables to be completed within the work in WP2. D4 is the present one:

Table 2. Deliverables in WP2 and current degree of completion

Nr	Deliverable	Due	Current degree of completion
D2	Application of the local criteria/standards and their differences for very low-energy and low energy houses in the participating countries	month 9	100%
D3	Principles of low-energy houses applicable in the participating countries and their applicability throughout the EU	month 17	100%
D4	Energy-demand levels and corresponding residential concept houses and the specific challenges of very low-energy houses in colder climates	month 17	100%

This deliverable is related to the work in this project by using the results of D2 and D3 and the knowledge of the participants as input to present comparisons, discussion and concept buildings.

The report finishes the work in WP2, which has the focus on definition of local concept houses for every country and the specific challenges in cold climates.

2.4 Contents of the report

In chapter 3 the calculations illustrating the level of energy requirements of the single countries' building regulations as well as comparison of the level of energy requirements in the different criteria for very low energy buildings is described and the results reported.

The discussion of "compensating" and "constant" energy requirements is dealt with in chapter 4, which also shows some examples of the effect of different impacts to the energy demand.

Chapter 5 on concept buildings contains descriptions of a one family house and an apartment block reaching two different energy levels in one climate per country. Only exceptions are Norway, for which two different climates have been processed, and Finland, for which three different climates have been processed.

3 CALCULATION METHODS AND ENERGY DEMAND LEVELS

3.1 Method of comparison

The first two deliveries of this WP, D2 and D3, showed requirements of existing very low energy building criteria (D2) and design guidelines very low energy buildings (D3). This delivery closes the work around the building requirements.

As it was shown in D2, the character of energy requirements and the boundary conditions differ radically between the countries. Also the calculation tools applied are different in all countries (with the exception of PHPP). This deliverable provides the quantitative comparison of the different regulations and criteria, because it is based on comparable calculations with as uniform input as possible for the different calculation tools.

For each climate 2 or 4 calculations are performed (refer also to Figure 1, which was sent to the partners as guideline and gives an illustration of the calculation work):

1. Calculation with a national tool is used to show compliance with the building regulations. The pre-defined U-values supplied by the work package leader, by which the building meets the international passive house criteria, are applied.
2. Calculation with a national tool is used to show compliance with the building regulations. The U-values are adapted to just meet the standard energy requirement of the national building regulation.
3. If local very low energy building criteria exist, the same calculation is performed with the tool used to show compliance with local very low energy building criteria. The pre-defined U-values supplied by the work package leader, by which the building meets the international passive house criteria, are applied.
4. Calculation with a tool used to show compliance with local very low energy building criteria. The U-values are adapted to just meet the local very low energy building criteria.

All returned U-values and answers were calculated a second time with PHPP to get comparable results – shown in Figure 2 to Figure 9.

The boundary conditions are also listed on chapter 5. The following pages show the results calculated by the partners. So are the results of the calculations shown and also special feedbacks or interesting points on the calculation is listed beneath.

Base of the calculations were the two buildings already used in parameter analysis in D3. The feedback of the participating countries showed, that the buildings have a good shape, as it took only very modest U-values to reach energy requirements of the building regulations.

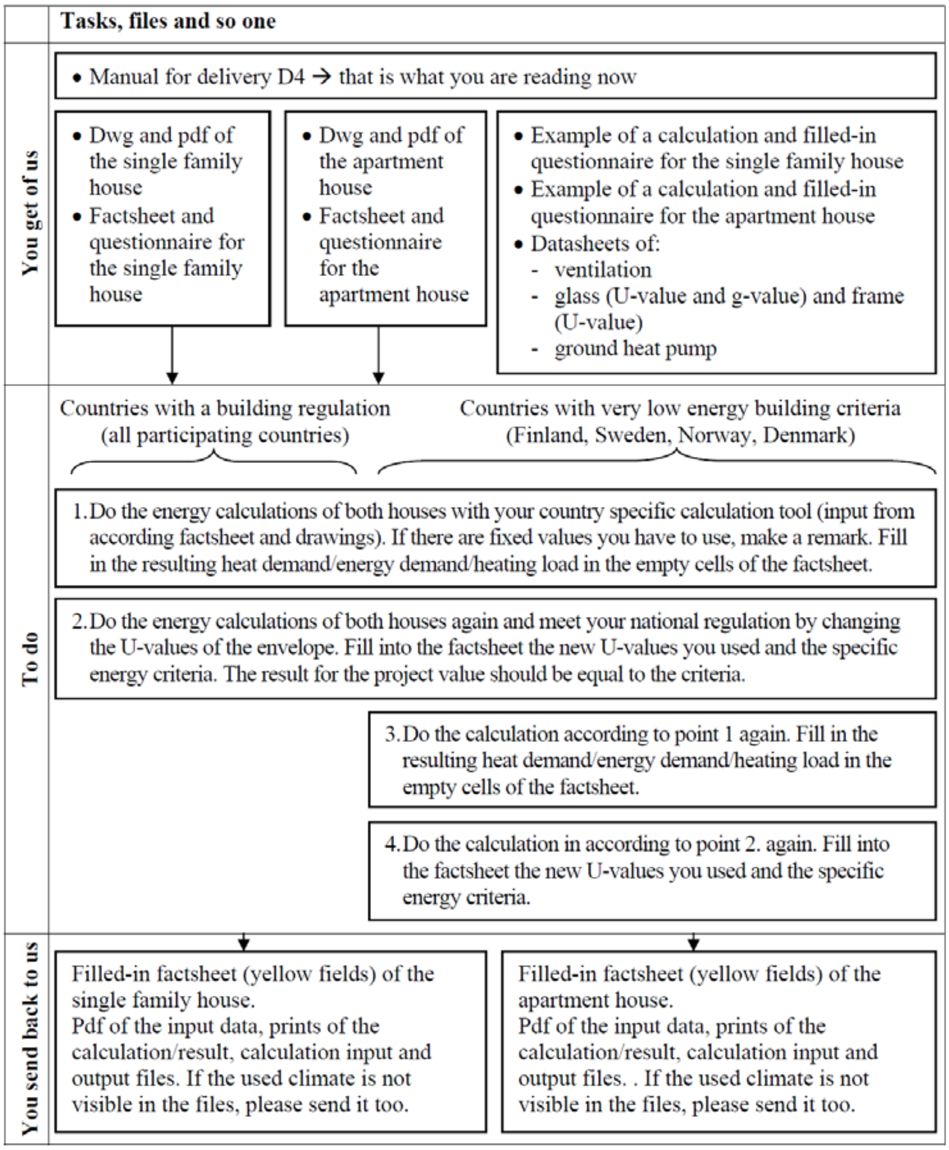


Figure 1. Step by step manual for the calculation work of the partners.

3.1.1 Overview of the calculation tools and input

As shown in Table 3 there exist a quite big range of calculation tools from dynamic simulation tools to calculations with monthly averages.

Table 3. Overview of the calculation tools applied

	Name of the calculation tool:	Calculation is based on:	Source of the climate:
Finland	IDA Indoor Climate and Energy (IDA ICE)	Dynamical calculation, the maximal time step can be chosen (here 1,5 h was used)	Jyväskylä 1979 climate data and wind profile of countryside for single family houses and wind profile of urban area for apartment houses Sodankylä 1979 climate data and wind profile of countryside for single family houses and wind profile of urban area for apartment houses
Sweden	VIP Energy (www.strusoft.com)	Hourly weather data	Normal year from SMHI (Swedish Meteorological and Hydrological Institute)
Norway	SIMIEN (www.Programbyggerne.no)	Hourly dynamic calculations	Country specific weather data, typical meteorological year
Estonia	BV2 (www.bv2.se) but it is a special version of this software made explicitly for the national code (i.e. some fixed values, default values for IHG etc...).	The calculation of the building heat balance in BV2 is based on the annual outdoor temperatures (temperature duration curves) based on hourly input data	The climate data used for whole Estonia is fixed by the national code (of energy efficiency of buildings) and is compiled from measured data from 1970 to 2000 (according to ISO 15927-4). (publication in English www.kirj.ee/public/va_te/eng-2006-1-4.pdf)
Lithuania			
Latvia	PHPP 2007	ISO 13790	Temperatures from building code and solar radiation from meteonorm software
Poland			
Denmark	Be06	EN13790	The authors of Be06 inform that the monthly values are based on the Danish Design Reference Year. This DRY is composed of selected months' actual weather data from the period 1975-1989 in Værløse by Copenhagen.

3.2 Results and comments from the different countries

In this chapter calculation results for the 2 or 4 cases are presented separately for each 10 locations and separately for single family house (SFH) and apartment house (AH). The results are summarized in the next chapter.

3.2.1 Finland

Results SFH Jyväskylä:

	1 fix U-values building reg.	2 var. U-values building reg.	3 fix U-values very low e.h.	4 var. U-values very low e.h.
Used area [m^2]: gross floor area	9,71x9,79 → 95,06	8,97x9,05 → 81,18	9,71x9,79 → 95,06	9,37x9,45 → 88,55
Roof [W/m^2K]	0,061	0,097	0,061	0,072
Walls [W/m^2K]	0,061	0,170	0,061	0,086
Floor slab [W/m^2K]	0,061	0,192	0,061	0,102
Door [W/m^2K]	0,9	0,9	0,9	0,9
Glass [W/m^2K]	0,43	1,0	0,43	0,7
Frame [W/m^2K]	0,68	1,0	0,68	0,7
Ventilation: Heat recovery [%]	80	80	80	80
Project space heat demand [kWh/m^2a]	15,6 (33%)	47,4 (100%)	15,6 (62%)	25,4 (102%)
Criteria space heat demand [kWh/m^2a]	47,4	47,4	25	25
Heat load [W/m^2]	-	-	-	-
Criteria heat load [W/m^2]	-	-	-	-
Project primary energy demand [kWh/m^2a]	-	-	73,3 (62%)	87,4 (74%)
Criteria for Primary energy demand [kWh/m^2a]	-	-	118,6	118,6

Results AH Jyväskylä:

	1 fix U-values building reg.	2 var. U-values building reg.	3 fix U-values very low e.h.	4 var. U-values very low e.h.
Used area [m^2]: gross floor area	44,49x10,40 → 462,7	44,01x9,92 → 436,6	44,49x10,40 → 462,7	44,15x10,06 → 444,1
Roof [W/m^2K]	0,080	0,096	0,080	0,079
Walls [W/m^2K]	0,080	0,168	0,080	0,114
Floor slab [W/m^2K]	0,080	0,198	0,080	0,109
Glass [W/m^2K]	0,90	0,90	0,90	0,90
Glass [W/m^2K]	0,43	1,0	0,43	0,8
Frame [W/m^2K]	0,68	1,0	0,68	0,8
Ventilation: Heat recovery [%]	80	80	80	80
Project space heat demand [kWh/m^2a]	16,7 (51%)	32,7 (100%)	16,7 (67%)	25,6 (102%)
Criteria space heat demand [kWh/m^2a]	32,7	32,7	25	25
Heat load [W/m^2]	-	-	-	-
Criteria heat load [W/m^2]	-	-	-	-
Project primary energy demand [kWh/m^2a]	-	-	80,9 (77%)	92,5 (88%)
Criteria for Primary energy demand [kWh/m^2a]	-	-	105,2	105,2

Results SFH Sodankylä:

	1 a) fix U-values building reg.	2 var. U-values building reg.	3 a) fix U-values very low e.h.	4 var. U-values very low e.h.
Used area [m^2]: gross floor area	9,71x9,79 → 95,06	8,97x9,05 → 81,18	9,71x9,79 → 95,06	9,37x9,45 → 88,55
Roof [W/m^2K]	0,040	0,097	0,040	0,072
Walls [W/m^2K]	0,061	0,170	0,061	0,086
Floor slab [W/m^2K]	0,061	0,192	0,061	0,08
Door [W/m^2K]	0,6	0,9	0,6	0,5
Glass [W/m^2K]	0,43	1,0	0,43	0,5
Frame [W/m^2K]	0,68	1,0	0,68	0,5
Ventilation: Heat recovery [%]	90	80	90	80
Project space heat demand [kWh/m^2a]	22,5 (34%)	66,2 (100%)	22,5 (75%)	29,6 (99%)
Criteria space heat demand [kWh/m^2a]	66,2	66,2	30	30
Heat load [W/m^2]	-	-	-	-
Criteria heat load [W/m^2]	-	-	-	-
Project primary energy demand [kWh/m^2a]	-	-	79,9 (58%)	91,5 (67%)
Criteria for Primary energy demand [kWh/m^2a]	-	-	137,3	137,3

a) With these data, the building reaches the Passive House Criteria in the chosen location, the City of Oulu (140.000 inhabitants). As weather data of Oulu was not available to the Finnish partner, data for Sodankylä (300 km north, 9000 inhabitants in the 11000 km^2 county) was applied. In this location the house does not reach the Passive House Criteria

Results AH Sodankylä:

	1 a) fix U-values building reg.	2 var. U-values building reg.	3 a) fix U-values very low e.h.	4 var. U-values very low e.h.
Used area [m^2]: gross floor area	44,49x10,40 → 462,7	44,01x9,92 → 436,6	44,49x10,40 → 462,7	44,15x10,06 → 444,1
Roof [W/m^{2}K]	0,040	0,096	0,080	0,079
Walls [W/m^{2}K]	0,060	0,168	0,080	0,114
Floor slab [W/m^{2}K]	0,060	0,198	0,080	0,08
Door [W/m^{2}K]	0,90	0,90	0,90	0,50
Glass [W/m^{2}K]	0,43	1,0	0,43	0,6
Frame [W/m^{2}K]	0,68	1,0	0,68	0,6
Ventilation: Heat recovery [%]	85	80	85	80
Project space heat demand [kWh/m^{2}a]	21,6 (45%)	48,4 (100%)	21,6 (72%)	30,5 (102%)
Criteria space heat demand [kWh/m^{2}a]	48,4	48,4	30	30
Heat load [W/m^2]	-	-	-	-
Criteria heat load [W/m^2]	-	-	-	-
Project primary energy demand [kWh/m^{2}a]	-	-	82,9 (69%)	97,1 (81%)
Criteria for Primary energy demand [kWh/m^{2}a]	-	-	120,6	120,6

a) With these data, the building reaches the Passive House Criteria in the chosen location, the City of Oulu (140.000 inhabitants). As weather data of Oulu was not available to the Finnish partner, data for Sodankylä (300 km north, 9000 inhabitants in the 11000 km^2 county) was applied. In this location the house does not reach the Passive House Criteria

Feedback on the calculation:

- For the country specific calculation, the reference U-values from 2010 were taken.
- The materialisation was refined:
  floor slab insulation, concrete, parquet
  wall gypsum board, insulation with wood stubs, insulation, brick
  roof gypsum board, insulation with wood stubs, insulation, gypsum board, roof covering
- Although VTT and RIL have defined very low energy standards with primary energy demands, but at least the primary energy factors are coming 2012 but it’s not yet decided what the factors are. For electricity the factor will be 2,0..,2,5.
- The northern climate (Oulu) had to be calculated with the climate from Sodankylä.

3.2.2 Sweden

Results SFH Stockholm:

	1 fix U-values building reg.	2 var. U-values building reg.	3 fix U-values very low e.h.	4 var. U-values very low e.h.
Used area [m^2]: overall internal dimensions	136,9	136,9	136,9	136,9
Roof [W/m^2K]	0,112	0,250	0,112	0,070
Walls [W/m^2K]	0,112	0,250	0,112	0,090
Floor slab [W/m^2K]	0,112	0,250	0,112	0,100
Door [W/m^2K]	0,90	0,90	0,90	0,90
Glass [W/m^2K]	0,50	0,90	0,5	0,50
Frame [W/m^2K]	0,68	2,00	0,68	0,68
Ventilation: Average air flow [m^3/h] Heat recovery [%] / With provision for 1m duct [%]	120 92/90	173 82/80	173 92/90	173 92/90
Project space heat demand [kWh/m^2a]	12,7	63,0	13,4	10,6
Criteria space heat demand [kWh/m^2a]	-	-	-	-
Heat load [W/m^2]	13,5	28,4	13,9 (116%)	12,0 (100%)
Criteria heat load [W/m^2]	-	-	12	12
Project net energy demand [kWh/m^2a]	45,8 (42%)	98,0 (89%)	48,4 (97%)	45,6 (91%)
Criteria for net energy demand [kWh/m^2a]	110	110	50	50
Project primary energy demand [kWh/m^2a]	50,4	105,5	54,9 (92%)	52,1 (87%)
Criteria for primary energy demand [kWh/m^2a]	-	-	60	60

Results AH Stockholm:

	1 fix U-values building reg.	2 var. U-values building reg.	3 fix U-values very low e.h.	4 var. U-values very low e.h.
Used area [m^2]: overall internal dimensions	2181,6	2181,6	2181,6	2181,6
Roof [W/m^2K]	0,140	0,300	0,140	0,120
Walls [W/m^2K]	0,140	0,300	0,140	0,120
Floor slab [W/m^2K]	0,140	0,300	0,140	0,120
Glass [W/m^2K]	0,90	0,90	0,90	0,90
Glass [W/m^2K]	0,70	1,0	0,70	0,70
Frame [W/m^2K]	1,00	2,0	1,00	1,00
Ventilation: Average air flow [m^3/h] Heat recovery [%] / With provision for 1m duct [%]	2400 77/75	2749 62/60	2749 77/75	2749 77/75
Project space heat demand [kWh/m^2a]	8,0	28,2	8,8	7,6
Criteria space heat demand [kWh/m^2a]	-	-	-	-
Heat load [W/m^2]	10,2	20,8	10,6 (106%)	9,5 (95%)
Criteria heat load [W/m^2]	-	-	10	10
Project net energy demand [kWh/m^2a]	42,1 (38%)	63,4 (58%)	43,7 (87%)	42,5 (85%)
Criteria for net energy demand [kWh/m^2a]	110	110	50	50
Project primary energy demand [kWh/m^2a]	47,7	70,1	50,1 (84%)	48,9 (82%)
Criteria for primary energy demand [kWh/m^2a]	-	-	60	60

Feedback on the calculation:

- For the country specific calculation, typical value for current construction were taken, which for this building results in a lower energy use than required.
- Heat load does consider free heat from appl. and persons.
- Lighting and household elec. devices are excluded in the net energy demand

3.2.3 Norway

Results SFH Oslo:

	1 fix U-values building reg.	2 var. U-values building reg.	3 fix U-values very low e.h.	4 var. U-values very low e.h.
Used area [m^2]: overall internal dimensions	135,8	135,8	135,8	135,8
Roof [W/m^{2}K]	0,121	0,15	0,121	0,121
Walls [W/m^{2}K]	0,121	0,22	0,121	0,121
Floor slab [W/m^{2}K]	0,121	0,24	0,121	0,121
Door [W/m^{2}K]	0,90	0,90	0,90	0,90
Glass [W/m^{2}K]	0,60	1,1	0,60	0,6
Frame [W/m^{2}K]	0,68	0,9	0,68	0,68
Ventilation: Average air flow [m^3/h]	163	163	163	163
Project space heat demand [kWh/m^{2}a]	22,6	54,7	27 (128%)	27 (128%)
Criteria space heat demand [kWh/m^{2}a]	-	-	21,1	21,1
Heat load [W/m^2]	21,1	34,8	21,3	21,3
Criteria heat load [W/m^2]	-	-	-	-
Project net energy demand [kWh/m^{2}a]	101,2 (74%)	134,3 (98%)	91 (120%)	91 (120%)
Criteria for net energy demand [kWh/m^{2}a]	136,8	136,8	76	76

Results AH Oslo:

	1 fix U-values building reg.	2 var. U-values building reg.	3 fix U-values very low e.h.	4 var. U-values very low e.h.
Used area [m^2]: overall internal dimensions	1965,6	1965,6	1965,6	1965,6
Roof [W/m^2K]	0,160	0,15	0,160	0,1
Walls [W/m^2K]	0,160	0,22	0,160	0,1
Floor slab [W/m^2K]	0,160	0,28	0,160	0,16
Glass [W/m^2K]	0,90	0,90	0,90	0,90
Glass [W/m^2K]	0,70	1,1	0,70	0,6
Frame [W/m^2K]	1,10	1,1	1,10	0,9
Ventilation: Average air flow [m^3/h]	3342	3342	3342	3342
Project space heat demand [kWh/m^2a]	15,3	24,6	19,7 (131%)	14,2 (95%)
Criteria space heat demand [kWh/m^2a]	-	-	15	15
Heat load [W/m^2]	18	22,6	18	13
Criteria heat load [W/m^2]	-	-	-	-
Project net energy demand [kWh/m^2a]	96,1 (80%)	105,9 (88%)	85,1 (137%)	77,2 (124%)
Criteria for net energy demand [kWh/m^2a]	120	120	62,2	62,2

Results SFH Tromsø:

	1 fix U-values building reg.	2 var. U-values building reg.	3 fix U-values very low e.h.	4 var. U-values very low e.h.
Used area [m^2]: overall internal dimensions	135,8	135,8	135,8	135,8
Roof [W/m^2K]	0,057	0,15	0,057	0,08
Walls [W/m^2K]	0,057	0,22	0,057	0,12
Floor slab [W/m^2K]	0,057	0,18	0,057	0,12
Door [W/m^2K]	0,90	0,90	0,90	0,90
Glass [W/m^2K]	0,43	0,6	0,43	0,43
Frame [W/m^2K]	0,68	0,68	0,68	0,68
Ventilation: Average air flow [m^3/h]	163	163	163	163
Project space heat demand [kWh/m^2a]	17,3	58,8	21,9 (72%)	30,1 (98%)
Criteria space heat demand [kWh/m^2a]	-	-	30,6	30,6
Heat load [W/m^2]	12,5	24,8	12,6	15,3
Criteria heat load [W/m^2]	-	-	-	-
Project net energy demand [kWh/m^2a]	95,3 (70%)	135,2 (99%)	85,5 (108%)	94,1 (119%)
Criteria for net energy demand [kWh/m^2a]	136,8	136,8	79,1	79,1

Results AH Tromsø:

	1 fix U-values building reg.	2 var. U-values building reg.	3 fix U-values very low e.h.	4 var. U-values very low e.h.
Used area [m^2]: overall internal dimensions	1965,6	1965,6	1965,6	1965,6
Roof [W/m^2K]	0,081	0,15	0,081	0,1
Walls [W/m^2K]	0,081	0,22	0,081	0,15
Floor slab [W/m^2K]	0,081	0,28	0,081	0,16
Glass [W/m^2K]	0,90	0,90	0,90	0,90
Glass [W/m^2K]	0,43	1,1	0,43	0,6
Frame [W/m^2K]	0,68	1,1	0,68	0,9
Ventilation: Average air flow [m^3/h]	3342	3342	3342	3342
Project space heat demand [kWh/m^2a]	9,7	34,2	14,3 (63%)	20,2 (89%)
Criteria space heat demand [kWh/m^2a]	-	-	22,6	22,6
Heat load [W/m^2]	10,5	19,1	10,7	12,9
Criteria heat load [W/m^2]	-	-	-	-
Project net energy demand [kWh/m^2a]	90,3 (75%)	115,3 (96%)	79,4 (113%)	85,5 (121%)
Criteria for net energy demand [kWh/m^2a]	120	120	70,5	70,5

Feedback on the calculation:

- There is just the climate of Oslo used for all very low energy building calculations in whole Norway.

3.2.4 Estonia

Results SFH Tallinn:

	1 fix U-values building reg.	2 var. U-values building reg.
Used area [m^2]: net floor area	130,6	130,6
Roof [W/m^{2}K]	0,101	0,51
Walls [W/m^{2}K]	0,101	0,51
Floor slab [W/m^{2}K]	0,101	0,51
Glass [W/m^{2}K]	0,90	1,1
Glass [W/m^{2}K]	0,43	2,0
Frame [W/m^{2}K]	0,68	2,0
Ventilation: Average air flow [m^3/h] Heat recovery [%] / With provision for 1m duct [%]	 197,5 92/90	 197,5 0
Project space heat demand [kWh/m^{2}a]	20,6	238,9
Criteria space heat demand [kWh/m^{2}a]	-	-
Heat load [W/m^2]	19	76
Criteria heat load [W/m^2]	-	-
Project primary energy demand [kWh/m^{2}a]	67,4 (37%)	180,0 (100%)
Criteria for primary energy demand [kWh/m^{2}a]	180	180

Results AH Tallinn:

	1 fix U-values building reg.	2 var. U-values building reg.
Used area [m^2]: net floor area	1915	1915
Roof [W/m^2K]	0,115	0,8
Walls [W/m^2K]	0,115	0,8
Floor slab [W/m^2K]	0,115	0,8
Glass [W/m^2K]	0,90	0,90
Glass [W/m^2K]	0,70	2
Frame [W/m^2K]	0,68	2
Ventilation: Average air flow [m^3/h] Heat recovery [%] / With provision for 1m duct [%]	2895,5 77/75	2895,5 0
Project space heat demand [kWh/m^2a]	12,9	159,2
Criteria space heat demand [kWh/m^2a]	-	-
Heat load [W/m^2]	14	54
Criteria heat load [W/m^2]	-	-
Project primary energy demand [kWh/m^2a]	74,5 (50%)	150,0 (100%)
Criteria for primary energy demand [kWh/m^2a]	150	150

Feedback on the calculation:

- No exact method for fixed shading input in national software, so default values (average 25% shading) used.
- Fixed ventilation airflow of 0,42 l/(s*m2) for dwellings as standard usage.
- Fixed deep ground temperature of 7 ºC with 1m of soil with lambda = 1,4 W/(mK) below floor construction.
- Fixed values for ground source heat pump COP-s.
- Because of low weighting factor for electricity the max allowed level of primary energy demand was not achieved only through changing the U-values. So ventilation with no HR was also used.

3.2.5 Lithuania

Results SFH Vilnius:

	1 fix U-values building reg.	2 var. U-values building reg.
Used area [m^2]: net floor area	172,04	172,04
Roof [W/m^{2}K]	0,103	0,16
Walls [W/m^{2}K]	0,103	0,2
Floor slab [W/m^{2}K]	0,103	0,25
Glass [W/m^{2}K]	0,90	1,6
Glass [W/m^{2}K]	0,43	1,6
Frame [W/m^{2}K]	0,68	
Spezial definitions	-	-
Project space heat demand [kWh/m^{2}a]	60,16 (95%)	122,22 (94%)
Criteria space heat demand [kWh/m^{2}a]	63,04	130,41

a) Energy declaration class B / b) Energy declaration class C

Results AH Vilnius:

	1 fix U-values building reg.	2 var. U-values building reg.
Used area [m^2]: net floor area	2181,1	2181,1
Roof [W/m^{2}K]	0,112	0,16
Walls [W/m^{2}K]	0,112	0,2
Floor slab [W/m^{2}K]	8,93	4
Glass [W/m^{2}K]	0,90	0,90
Glass [W/m^{2}K]	0,70	1,6
Frame [W/m^{2}K]	0,68	
Spezial definitions	-	-
Project space heat demand [kWh/m^{2}a]	72,02 (102%)	105,87 ()
Criteria space heat demand [kWh/m^{2}a]	70,13 a)	101,53 b)

a) Energy declaration class B / b) Energy declaration class C

Feedback on the calculation:

- The criteria are already indexed with the national energy declaration class

3.2.6 Latvia

Results SFH Riga:

	1 fix U-values building reg.	2 var. U-values building reg.
Used area [m²]: net floor area	128,5	128,5
Roof [W/m²K]	0,094	0,211
Walls [W/m²K]	0,094	0,317
Floor slab [W/m²K]	0,094	0,264
Glass [W/m²K]	0,90	0,90
Glass [W/m²K]	0,43	1,3
Frame [W/m²K]	0,68	2,1
Spezial definitions	-	-
Project space heat demand [kWh/m²a]	12	75
Criteria space heat demand [kWh/m²a]	-	-
Heat load [W/m²]	17	46
Criteria heat load [W/m²]	-	-

Results AH Riga:

	1 fix U-values building reg.	2 var. U-values building reg.
Used area [m²]: net floor area	1872,9	1872,9
Roof [W/m²K]	0,120	0,211
Walls [W/m²K]	0,120	0,317
Floor slab [W/m²K]	0,120	0,264
Glass [W/m²K]	0,90	0,90
Glass [W/m²K]	0,43	1,3
Frame [W/m²K]	0,68	2,2
Spezial definitions	-	-
Project space heat demand [kWh/m2a]	11	44
Criteria space heat demand [kWh/m2a]	-	-
Heat load [W/m2]	14	30
Criteria heat load [W/m2]	-	-

Feedback on the calculation:

- Latvian building code LBN 002-01 specified normative heat losses through building envelope that must not exceed certain level (Ht, W/K) and also it's specified minimum U values that should be reached for different constriction parts. Normative heat losses through building envelope are calculated using normative U values. In this calculation normative U - values has been used.
- At the moment there is no official definition on low energy building in Latvia. However new program in the Ministry of the Environment for financing additional costs for Passive and Low-Energy Buildings is on the way. Competition rules are worked out now, and competition itself will be announced at the end of September or October. At the moment it is proposed that annual heating requirement should be less than 35 kWh/(m^{2}a)
- According the Latvian legislation set point temperature for residential buildings is +18°C. Also in this case +18°C was used as interior temperature during heating season.

3.2.7 Poland

Results SFH Warsaw:

	1 fix U-values building reg.	2 var. U-values building reg.
Used area [m^2]: net floor area	133,18	133,18
Roof [W/m^{2}K]	0,112	0,57
Walls [W/m^{2}K]	0,112	0,57
Floor slab [W/m^{2}K]	0,112	0,57
Glass [W/m^{2}K]	0,90	0,90
Glass [W/m^{2}K]	0,50	1,10
Frame [W/m^{2}K]	0,68	1,60
Ventilation: Average air flow [m^3/h]	185	185
Project space heat demand [kWh/m^{2}a]	14,2	109,8
Criteria space heat demand [kWh/m^{2}a]	-	-
Heat load [W/m^2]	18,9	67,7
Criteria heat load [W/m^2]	-	-
Project primary energy demand [kWh/m^{2}a]	58,1 (39%)	149,4 (99%)
Criteria for primary energy demand [kWh/m^{2}a]	150	150

Results AH Warsaw:

	1 fix U-values building reg.	2 var. U-values building reg.
Used area [m^2]: net floor area	1909,72	1909,72
Roof [W/m^2K]	0,130	0,7
Walls [W/m^2K]	0,130	0,7
Floor slab [W/m^2K]	0,130	0,7
Glass [W/m^2K]	0,90	0,90
Glass [W/m^2K]	0,70	1,1
Frame [W/m^2K]	1,10	1,6
Ventilation: Average air flow [m^3/h]	2700	2700
Project space heat demand [kWh/m2a]	10	55,2
Criteria space heat demand [kWh/m2a]	-	-
Heat load [W/m2]	18	43,8
Criteria heat load [W/m2]	-	-
Project primary energy demand [kWh/m2a]	60,2 (58%)	103,2 (99%)
Criteria for primary energy demand [kWh/m2a]	103,9	103,9

Feedback on the calculation:

- The criteria are already indexed with the national energy declaration class

3.2.8 Denmark

Results SFH Copenhagen:

	1 fix U-values building reg.	2 var. U-values building reg.	3 a) fix U-values very low e.h.	4 var. U-values very low e.h.
Used area [m²]: cross floor area	172,04	172,04	172,04	172,04
Roof [W/m²K]	0,127	0,26	0,127	0,26
Walls [W/m²K]	0,127	0,26	0,127	0,26
Floor slab [W/m²K]	0,127	0,26	0,127	0,26
Door [W/m²K]	0,90	0,90	0,90	0,90
Glass [W/m²K]	0,70	0,70	0,70	0,70
Frame [W/m²K]	0,68	0,68	0,68	0,68
Spezial definitions	-	-	-	-
Project space heat demand [kWh/m²a]			3,3	34,4
Criteria space heat demand [kWh/m²a]			-	-
Heat load [W/m²] (just opaque envelope)	3,5 (50%)	7,0 (100%)	3,5 (50%)	7,0 (100%)
Criteria heat load [W/m²] (just opaque envelope)	7,0	7,0	7,0	7,0
Project primary energy demand [kWh/m²a]	21,8 (26%)	32,1 (39%)	21,8 (53%)	32,1 (78%)
Criteria for primary energy demand [kWh/m²a]	82,8	82,8	41,4	41,4

a) The idea of this step was to use any special tool specifically for very low energy buildings to calculate the heat load and primary energy demand for the pre-defined building, which meets the passive house criteria. In the Danish case the same program is used to prove compliance with standard energy requirements as well as the very low energy building class of the building regulations. Therefore column 1 and 3 shows the exact same characteristics.

Results AH Copenhagen:

	1 fix U-values building reg.	2 var. U-values building reg.	3 a) fix U-values very low e.h.	4 var. U-values very low e.h.
Used area [m^2]: cross floor area	2231,6	2231,6	2231,6	2231,6
Roof [W/m^2K]	0,175	0,30	0,175	0,15
Walls [W/m^2K]	0,175	0,30	0,175	0,15
Floor slab [W/m^2K]	0,175	0,30	0,175	0,15
Glass [W/m^2K]	0,90	0,90	0,90	0,90
Glass [W/m^2K]	0,80	0,80	0,80	0,80
Frame [W/m^2K]	1,20	1,20	1,20	1,20
Spezial definitions	-	-	-	-
Project space heat demand [kWh/m^2a]			3,8	2,8
Criteria space heat demand [kWh/m^2a]			-	-
Heat load [W/m^2] (just opaque envelope)	4,8 (60%)	7,8 (98%)	4,8 (60%)	4,1 (51%)
Criteria heat load [W/m^2] (just opaque envelope)	8	8	8	8
Project primary energy demand [kWh/m^2a]	36 (51%)	39,9 (56%)	36 (101%)	35,4 (100%)
Criteria for primary energy demand [kWh/m^2a]	71	71	35,5	35,5

a) The idea of this step was to use any special tool specifically for very low energy buildings to calculate the heat load and primary energy demand for the pre-defined building, which meets the passive house criteria. In the Danish case the same program is used to prove compliance with standard energy requirements as well as the very low energy building class of the building regulations. Therefore column 1 and 3 shows the exact same characteristics.

Feedback on the calculation:

- In the mandatory Danish calculation tool, Be06, an internal heat gain of 5 W/m² is applied, which means that the heat demand is from the beginning very low. The idea of possibly only changing the U-values to meet the energy requirements is not optimal for a building with an already very low heat demand.

3.3 Regulations and criteria in comparison

The calculations performed show a comparison between the different energy requirements and illustrate quite big differences in the way of calculating. Some of the results are illustrated and compared in the following graphs, separately for the single family and the apartment house:

- the blue column is (with few exceptions) the 15 kWh/m²/a heat demand of the international passive house criteria or the characteristics (U-values etc.), which it take to meet this requirement
- the brown column is the heat demand calculated with the same tool (PHPP/EN13790) for a building which according to the partners' calculations meets local very low energy building criteria
- the green column is the heat demand calculated with the same tool (PHPP/EN13790) for a building, which according to the partners' calculations just meets national building regulations

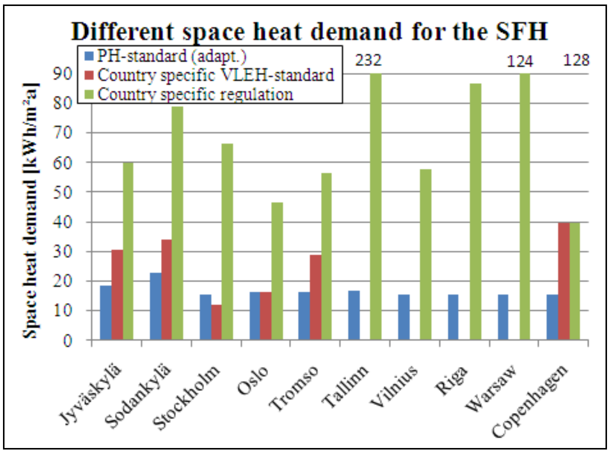


Figure 2. Comparison of space heat demand

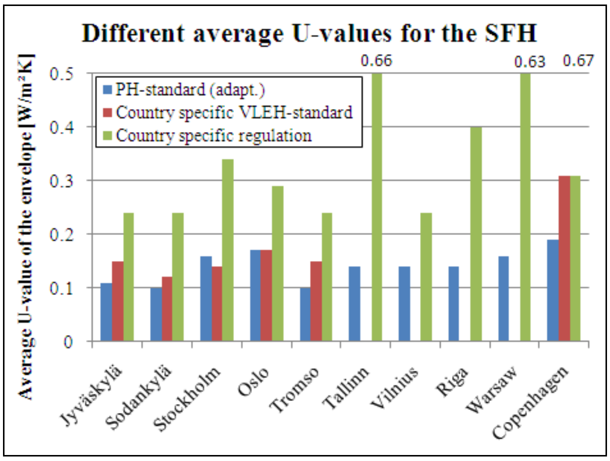


Figure 3. Comparison of the necessary average U-value for the envelope.

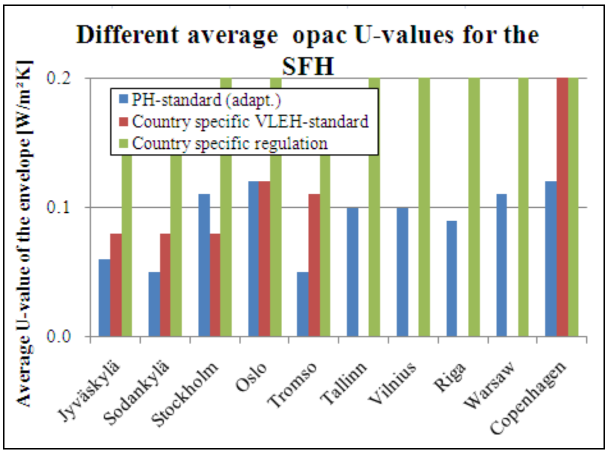


Figure 4. Comparison of the necessary opaque U-value

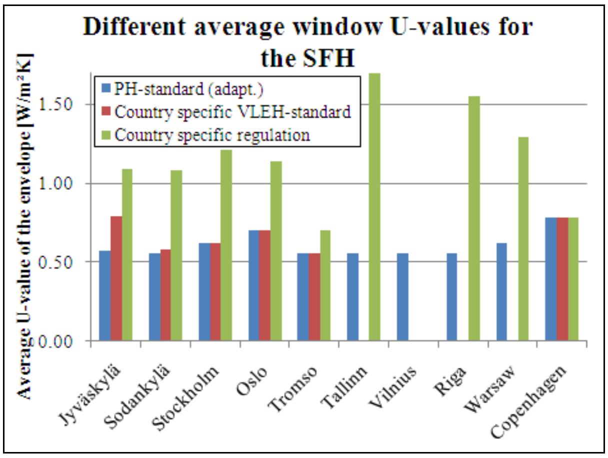


Figure 5. Comparison of the necessary window U-value

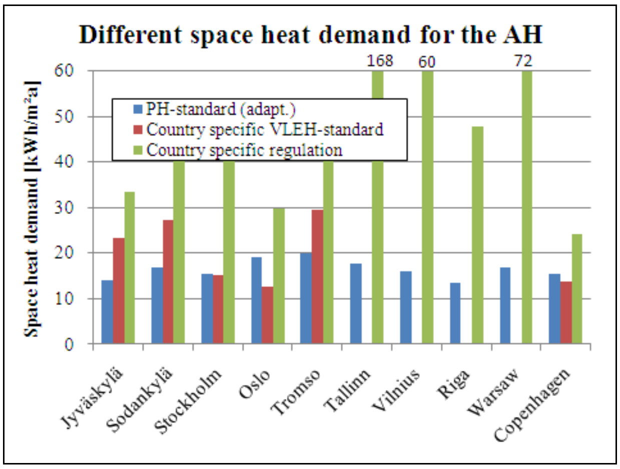


Figure 6. Comparison of space heat demand

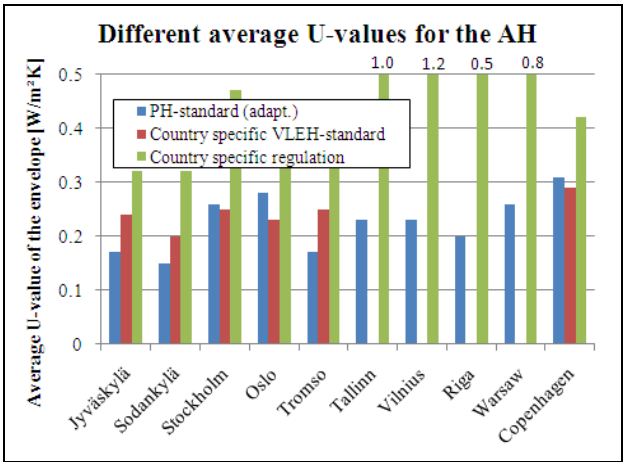


Figure 7. Comparison of the necessary average U-value for the envelope

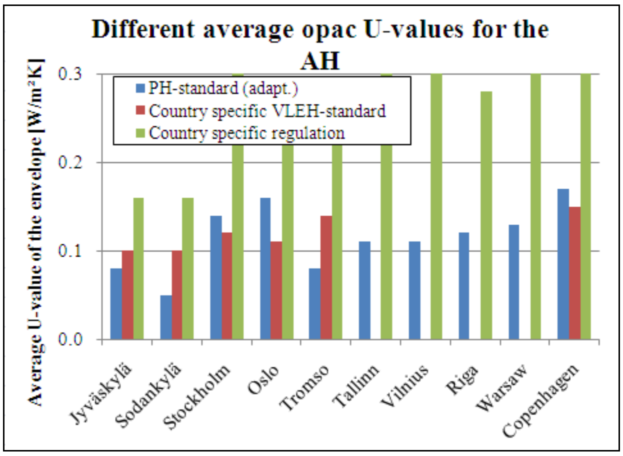


Figure 8. Comparison of the necessary opaque U-value

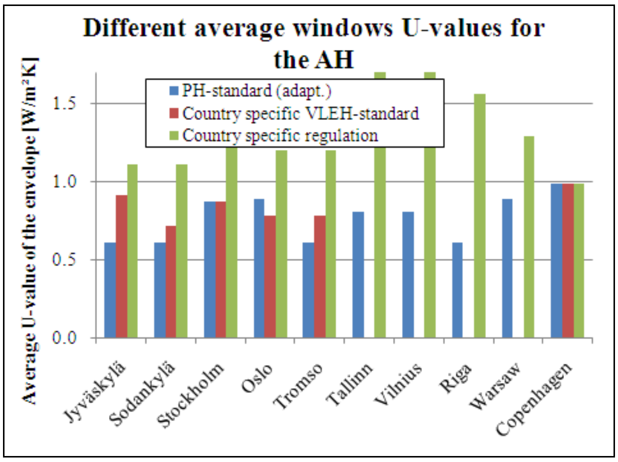


Figure 9. Comparison of the necessary windows U-value

The visualization shows that there are big differences between the countries' building regulations, around a factor 5 between the lowest and highest limits for these buildings as examples.

For the very low energy building criteria, the differences are substantially smaller. This corresponds to the qualitative observations of D2.

4 CROSS-BORDER ENERGY CRITERIA

As documented in D2 numerous substantially different very low energy building criteria (and regular building regulation energy requirements) exist, in some countries even several. This makes comparisons across borders (and organisations) difficult, and more important, they work as a technical barrier to trade.

This gave an impression that international criteria in general are not welcomed, but according to the grant agreement, we will still consider conditions for cross-border criteria.

So basically: What are energy requirements all about? Some of the most common positions are:

- “Energy requirements are also about comfort”. This position leads to the conclusion that the (highest) U-values must be lower in colder climates, or to even more functional requirement
- “Energy requirements should reflect optimal solutions”. Following this principle, one should look for simplified solutions, e.g. heating alone by the minimal air supply, or utilise phenomena which already occur locally, e.g. the availability of sauna in most new Finnish homes
- “Energy requirements must make the same components applicable in all climates”. This demand is most precisely satisfied by defining the requirements to the components directly rather than fitting energy requirements

Of course energy requirements are also about vulnerability to changes in the energy supply – and about environmental effects.

4.1 Starting point for two sets of criteria

Basically one can question, if, or how much, energy requirements should compensate for different climate, indoor temperature, ventilation air flow etc. One position is that the requirements should compensate partly or fully for some or “all” influences, another position is that it is fair enough to require more insulation in colder climates.

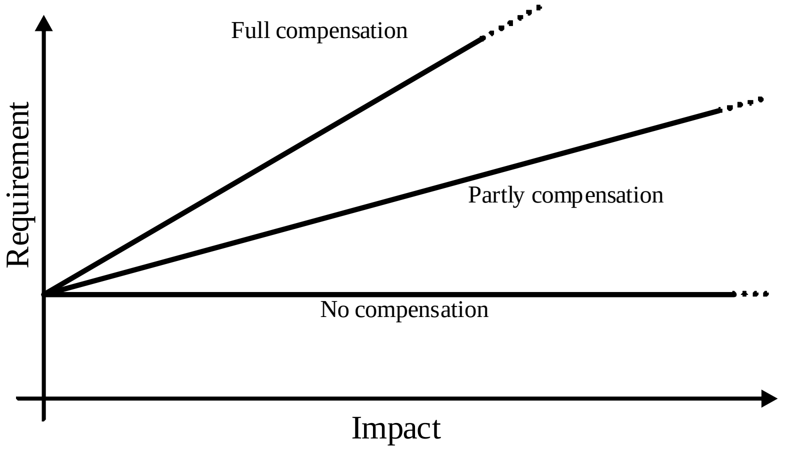


Figure 10. Principal relation between impact and requirement

In D2 the passive house criteria (as defined by PHI) were the only ones to be applied across borders. We will cover the full range by letting these criteria stand as the “climate-independent” or “non-compensating” variant, and we will consider mechanisms, which could form background for “compensating” very low energy building criteria.

4.2 “Compensating” criteria

The calculated energy demands and U-values etc. of chapter 3 reflect of course the temperature and the solar radiation of each climate. But which kind of compensations can be imagined?

- **Outdoor temperature**. A dependency of the energy requirements on annual mean temperature is already implemented in some participating countries (apparently most systematically in the Norwegian standard for very low energy buildings), but using the mean temperature of the coldest 5-7 months would be more relevant. Figure 11 and Figure 12 illustrate the effect

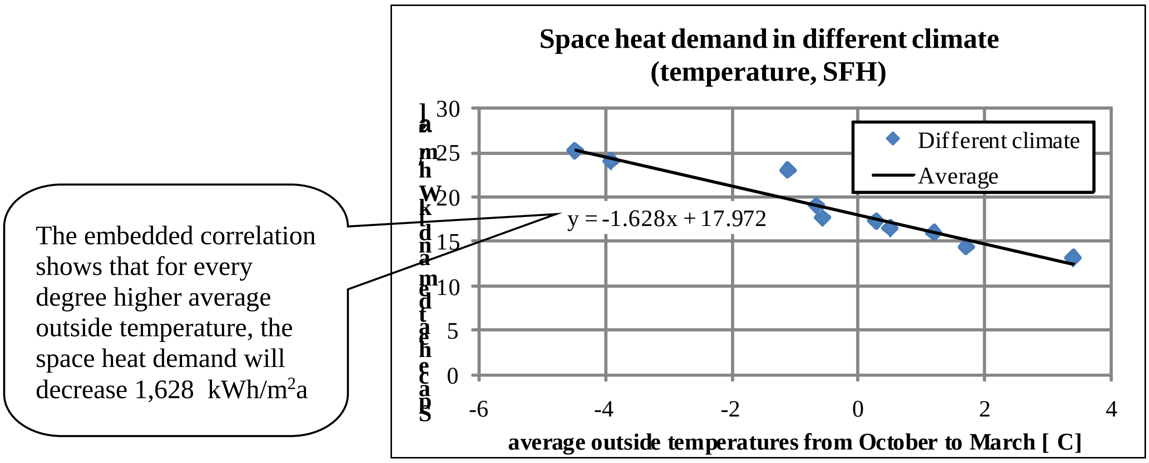


Figure 11. Influence of the outside temperature to the space heat demand for the single family house. The calculation is performed without windows (no influence of the solar radiation).

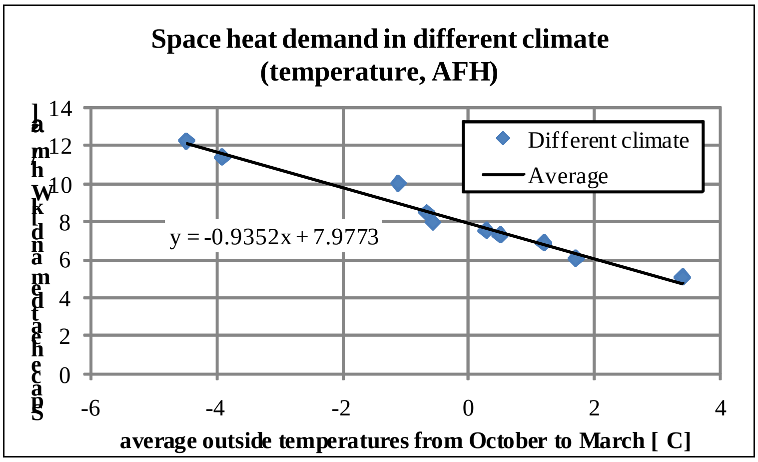


Figure 12. Influence of the outside temperature to the space heat demand for the apartment house. The calculation is performed without windows (no influence of the solar radiation).

- **Solar radiation**. For very Northern locations an inclusion of the solar radiation to the criteria could be relevant. Figure 12 and Figure 14 illustrate the effect

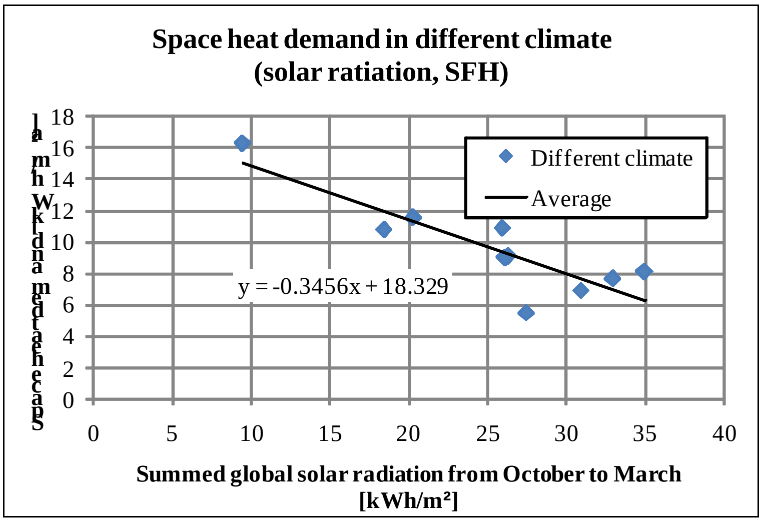


Figure 13. Influence of solar radiation to the space heat demand for the single family house. There is a fixed temperature (of Copenhagen) applied by the same window area (1% north, 6% east, 54% south and 6 west).

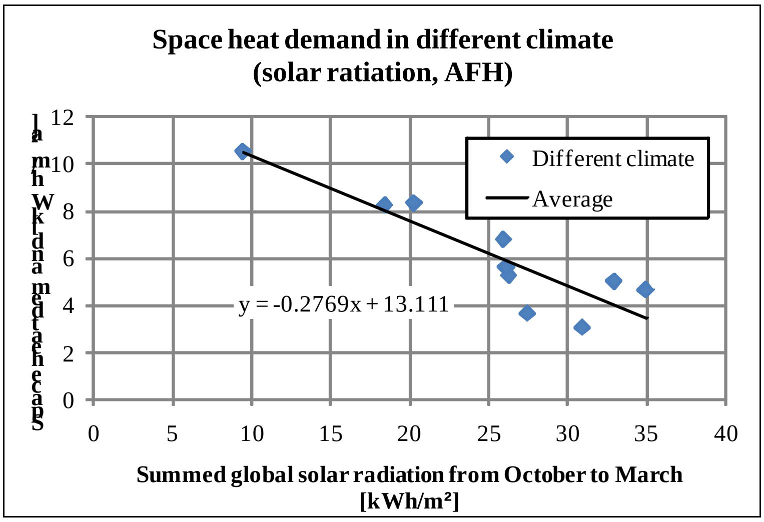


Figure 14. Influence of solar radiation to the space heat demand for the apartment house. There is a fixed temperature (of Copenhagen) applied by the same window area (14% north and 52% south).

- **Shading**. Shades from natural obstacles (mountains etc.) or other buildings could be compensated for
- **Indoor temperature**. If a higher temperature is required, the limit for the energy demand is increased
- **Increased ventilation**. If increased ventilation is required, the limit for the energy demand is increased (e.g. in Danish building regulations)

- **Extended hours of use**. If there is a longer than normal time of use, the limit for the energy demand is increased
- **Internal heat gains/special equipment**. With higher internal heat gains, the requirement for the heat demand might be reduced, but if it results from special, energy consuming equipment, an energy requirement including this equipment might be increased.
- **Compactness** resp. size of the building and/or number of storeys (compensation in small buildings), see Figure 15 and Figure 16. Volume to floor area ratio or envelope area to floor area ratio could have some influence in "compensating" criteria (e.g. in Danish present respectively former building regulations). An argument for compensating for the shape is that energy requirements should not limit the architectural possibilities. It is also argued that architecture will have to develop in order to meet the energy requirements

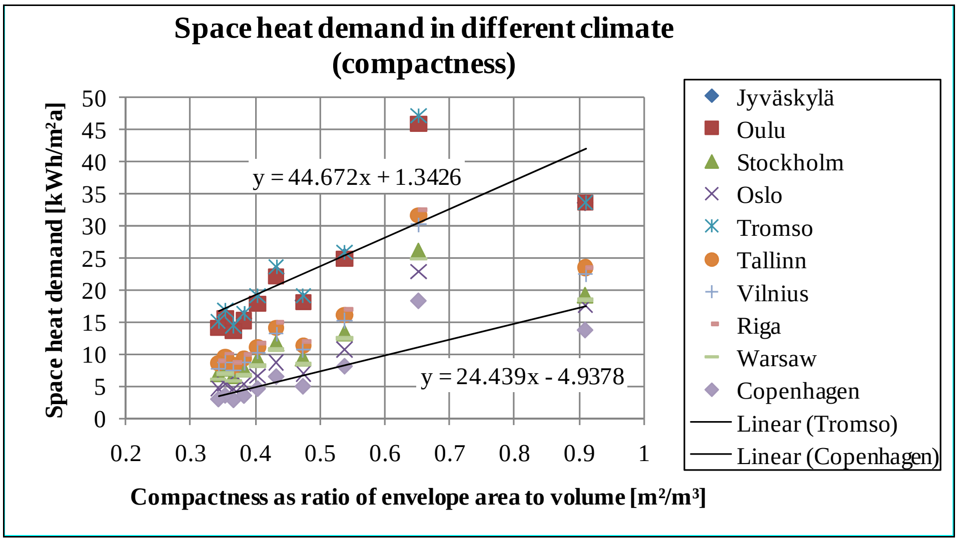


Figure 15. Influence of the building compactness for some exemplary geometries (envelope area to volume ratio)

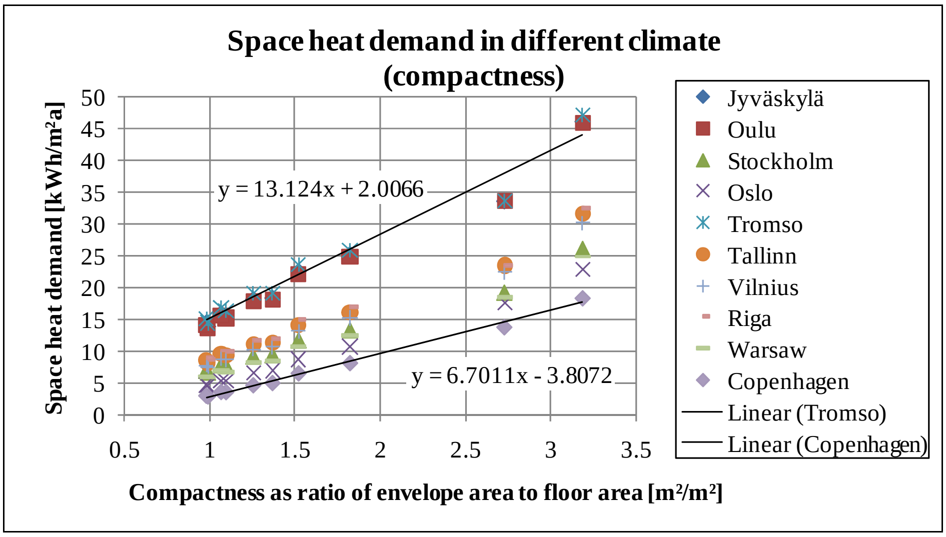


Figure 16. Influence of the building compactness for some exemplary geometries (envelope area to floor area)

4.3 Discussion

These examples illustrate some of the issues which could be – and locally have been – considered to compensate for in a set of climate adapted or “forgiving” energy criteria for very low energy buildings.

But there is not really an “absolute” answer as to the question, exactly which parameters should be included, much more it would be the result of a political discussion: “What is more common in my country”, “What is our building industry capable of or willing to do” etc.

The other principal alternative is fixed criteria, as the passive house criteria defined by PHI. The passive house criteria are exposed to the critique that they cannot be met everywhere.

But if energy criteria compensate only partly, there will still be some cases, where buildings cannot meet the criteria.

If the energy criteria compensate perfectly, any building could be realised anywhere and still meet the criteria. This might be looked upon as devaluating such criteria.

4.3.1 Consequence for the concept houses

In conclusion both fixed criteria and compensating criteria are subject to critique, and no specific set of compensations can be recommended.

As a consequence we have in the following chapter, which describes the concept buildings, chosen the two “edges” of Figure 10. Principal relation between impact and requirement.

5 DESCRIPTION OF THE CONCEPT HOUSES

In chapter 5 of D3 we looked at the energy consumption and U-values from parameter studies performed for two example buildings, parallel to the considerations in the former chapter (4) in this report, D4. On the basis of all these calculations – and considerations in previous chapters – the two presented concept house types in the following represents the upper and lower level of criteria to be applied as a very low energy concept building in the Northern European locations.

1. One approach is the perfect compensating strategy for climate adapted criteria. This was illustrated by calculating the heat demand for a building, which meets passive house criteria in a moderate climate (e.g. Copenhagen) and keep all characteristics trough all NorthPass climates.
2. The other alternative is calculating the necessary U-values etc. to meet passive house criteria in each of the NorthPass climates

This chapter describes the single family houses and apartment block used for the calculations and summarises the relevant characteristics for the two approaches, again separately for the single family and the apartment house.

5.1.1 Single family house

The main focus in the selection of the over all design was on the optimised building envelope. It therefore has a compact shape and the main window area is orientated to the south, which in D3 was proven optimal in all the climates investigated. The values of shape and size were fixed.

The north façade has very little window area. The ratio of glass area to window area is maximised and in rooms with several windows, some of these are left non-openable. A balcony and an overhang shield the building from too big heat gains during summer. Manually external blinds should be applied.

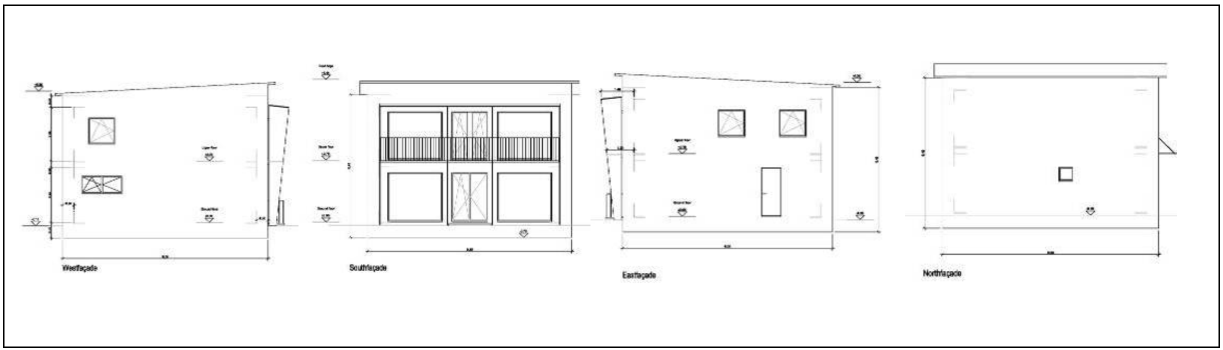


Figure 17. West, South, East and North façade of the example single family house.
Source: More detailed information about the source is available in the appendix

Table 4.Pre-defined values for the single family house

General information	
Numbers of dwellings	1
Inside measurements with interior walls per floor [m^2]	8,2 x 8,28 =67,90
Gross area per floor [m^2]	9,2 x 9,35 =86,02
Dimensions	
Levels	2
Inside width [m] / outside width [m]	8,28 / 9,35
Inside length [m] / outside length [m]	8,20 / 9,20
Height [m]	6,45
Ratios	
Envelope area / gross floor area [-]	2,39
Envelope area / gross volume [1/m]	0,74
Window size per façade	
South (Front) [m^2] / [%]	32,21 / 54
East [m^2] / [%]	3,38 / 6
North [m^2] / [%]	0,49 / 1
West [m^2] / [%]	3,42 / 6
Average glazed fraction of the windows [%] (each window has a surrounding frame from 100 mm width, therefore are 40mm visible on the top and sides and 80mm on the bottom)	79
Shading	
Horizontal shading [degrees]	5°
Overhang shading (South) [m]	1,46 and 1,20
Overhang shading [m]	0,15
Reveal shading [m]	0,15
U-values / materialisation	
Roof [W/m^2K]	Depending on country specific demand
Walls [W/m^2K]	
Floor slab [W/m^2K]	
Ground reduction factor [-]	
Door[W/m^2K]	
Glass [W/m^2K]	
Frame [W/m^2K]	
Thermal bridge spacer [W/mK]	0,03
Thermal bridge window installation [W/mK] (992 m)	0,01
Thermal bridge roof to wall (eaves, verge) [W/mK] (108,6 m)	-0,05
Thermal bridge wall corner [W/mK] (4 x 14,82 m)	-0,05
Thermal bridge foundation [W/mK] (108,6 m)	0,00
Also when the U-values are changed the thermal bridges should keep like they are.	
g-value window	0,49
Materialization floor slab	insulation, concrete
Materialization wall	insulation, concrete, brick or insulation, wood
Materialization roof	insulation, wood
Climate	country specific climate
Ventilation	
Average air flow [m^3/h] – if no other requests	120
Heat recovery [%] / With provision for 1m duct [%]	92 / 90
Air leakage at 50 Pascal, n_{50} [1/h]	0,4

Domestic hot water (DHW) (no recommendation, use local or given value)	Use of water saving equipment is required
Heating by geothermal heat pump	
EER of heating by the heat pump	3
EER of DHW by the heat pump	2,7
Heat supply by	radiator with thermostatic valve
Electricity (no recommendation use local or given value)	Use of electric saving appliance is required like A/A+ declaration on white goods, very low energy circulation pumps and so one
Cooling	
For this building is no active cooling system needed to guarantee thermal comfort in summer. There is a outside shading which can be operated manually.	

5.1.2 Apartment house

Also for the apartment house, the focus is on the optimal building envelope. Compact shape and the main window area is orientated to the south. The north façade has some windows, but the size is reduced. Due to the idea of a same usage the dwellings are all orientated north to south. The solar gains are divided to every dwelling in the same size and there is no misbalance which would make the heat supply more difficult.

The ratio of glass area to window area is maximised and in rooms with several windows, some of these are left non-openable. A balcony and an overhang shield the building from too big heat gains during summer. Manually external blinds should be applied.

Figure 18. South and east façades of the example apartment house.
Source: More detailed information about the source is available in delivery D3 appendix

Table 5. Pre-defined values for the apartment house

General information	
Numbers of dwellings	20
Inside measurements with interior walls per floor [m^2]	43,2x10,1=436,32
Gross area per floor [m^2]	44,2x11,1=490,62
Dimensions	
Levels	5
Inside width [m] / outside width [m]	43,19 / 44,19
Inside length [m] / outside length [m]	10,10 / 11,10
Height [m]	14,82

Ratios	
Envelope area / gross floor area [-]	1,12
Envelope area / gross volume / [1/m]	0,38
Window size per façade	
South (Front) [m^2] / [%]	341,6 / 52
East [m^2] / [%]	0 / 0
North [m^2] / [%]	90,1 / 14
West [m^2] / [%]	0 / 0
Average glazed fraction of the windows [%] (each window has a surrounding frame from 100 mm width, therefore are 40mm visible on the top and sides and 80mm on the bottom)	78

Shading	
Horizontal shading [degrees]	5°
Overhang shading (South) [m]	1,95
Overhang shading [m]	0,15
Reveal shading [m]	0,15
U-values / materialisation	
Roof [W/m^2K]	Depending on country specific demand
Walls [W/m^2K]	
Floor slab [W/m^2K]	
Ground reduction factor [-]	
Door[W/m^2K]	
Glass [W/m^2K]	
Frame [W/m^2K]	
Thermal bridge spacer [W/mK]	0,033
Thermal bridge window installation [W/mK] (992 m)	0,01
Thermal bridge roof to wall (eaves, verge) [W/mK] (108,6 m)	-0,05
Thermal bridge wall corner [W/mK] (4 x 14,82 m)	-0,05
Thermal bridge foundation [W/mK] (108,6 m)	0,00
Also when the U-values are changed the thermal bridges should keep like they are.	
g-value window	0,49
Materialization floor slab	insulation, concrete
Materialization wall	insulation, concrete, brick or insulation, wood
Materialization roof	insulation, wood
Climate	country specific climate
Ventilation	
Average air flow [m^3/h] – if no other requests	20 x 120 = 2400
Heat recovery [%] / With provision for 1m duct [%]	77 / 75
Air leakage at 50 Pascal, n_{50} [1/h]	0,4
Domestic hot water (DHW) (no recommendation, use local or given value)	Use of water saving equipment is required
Heating by geothermal heat pump	
EER of heating by the heat pump	3
EER of DHW by the heat pump	2,7
Heat supply by	radiator with thermostatic valve

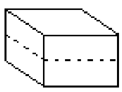
Electricity (no recommendation use local or given value)	Use of electric saving appliance is required like A/A+ declaration on white goods, very low energy circulation pumps and so one
Cooling	
For this building is no active cooling system needed to guarantee thermal comfort in summer. There is a outside shading which can be operated manually.	

5.2 The concept houses with constant characteristics

For the first approach of calculating the heat demand of a building with the same components in all 10 different climates was calculated. The buildings meet the passive house criteria in Copenhagen. .

Table 6. Factsheet for the building design characteristics (Copenhagen with a few adaptations)

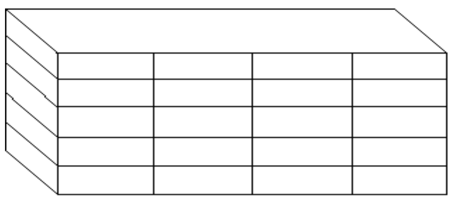
Single family house
(1 dwelling, 96 m² gross area)



Constraints:

U-value opaque envelope	< 0,13 W/m²K
U-value glass	< 0,7 W/m²K
U-value frame	< 1,0 W/m²K
Heat recovery efficiency	> 85%
Air flow (country specific)	≈ 120 m³/h
windows to south	30% - 50%
windows to east/west	< 15%
windows to north	< 5%

Appartment house
(20 dwellings, 2453 m² gross area)



Constraints:

U-value opaque envelope	< 0,15 W/m²K
U-value glass	< 0,7 W/m²K
U-value frame	< 1,2 W/m²K
Heat recovery efficiency	> 75%
Air flow (country specific)	≈ 2400 m³/h
windows to south	30% - 50%
windows to east/west	< 15%
windows to north	< 5%

Specific points: Take a look on the country specific points in the following factsheets.

These characteristics are expected to be rather affordable in all the climates of the investigation. However the heating load of the buildings will mostly be too high for the simplified supply air heating solution.

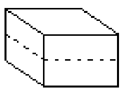
5.3 The concept houses with fixed heat demand

For the second approach, in order to set the challenging goal for the very low energy building design, the buildings are optimised to reach the fixed passive house criteria in each of the investigated climates. The fact sheets below illustrate what it takes in each of these climates.

5.3.1 The concept houses for Jyväskylä

Table 7. Factsheet building design characteristics for Jyväskylä

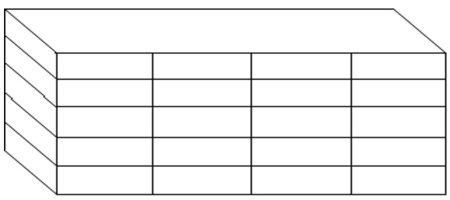
Single family house
(1 dwelling, 96 m^2 gross area)



Constraints:

U-value opaque envelope	< 0,08 W/m^2K
U-value glass	< 0,5 W/m^2K
U-value frame	< 1,0 W/m^2K
Heat recovery efficiency	> 85%
Air flow (country specific)	≈ 120 m^3/h
Windows to the south	30-50%
Windows to the east/west	< 10%
Windows to the north	< 5%

Appartment house
(20 dwellings, 2453 m^2 gross area)



Constraints:

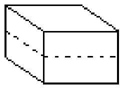
U-value opaque envelope	< 0,10 W/m^2K
U-value glass	< 0,5 W/m^2K
U-value frame	< 1,0 W/m^2K
Heat recovery efficiency	> 80%
Air flow (country specific)	≈ 2400 m^3/h
Windows to the south	30-50%
Windows to the east/west	< 10%
Windows to the north	< 5%

Specific points:	Be aware of frost and permafrost: at the ground, by using earth collector for heat pump or ventilation and on the heat recovery. → Earth brine pre heating and rotating heat recovery with humidity transfer is recommended for the ventilation

5.3.2 The concept houses for Stockholm

Table 8. Factsheet building design characteristics for Stockholm

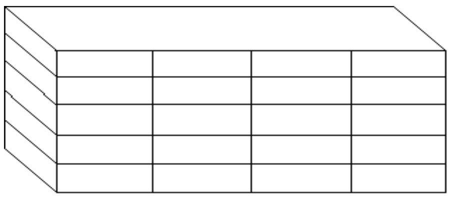
Single family house
(1 dwelling, 96 m^2 gross area)



Constraints:

U-value opaque envelope	< 0,11 W/m^2K
U-value glass	< 0,7 W/m^2K
U-value frame	< 1,0 W/m^2K
Heat recovery efficiency	> 85%
Air flow (country specific)	≈ 120 m^3/h
Windows to the south	40-60%
Windows to the east/west	< 20%
Windows to the north	< 5%

Appartment house
(20 dwellings, 2453 m^2 gross area)



Constraints:

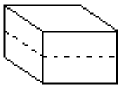
U-value opaque envelope	< 0,14 W/m^2K
U-value glass	< 0,7 W/m^2K
U-value frame	< 1,0 W/m^2K
Heat recovery efficiency	> 80%
Air flow (country specific)	≈ 2400 m^3/h
Windows to the south	40-60%
Windows to the east/west	< 20%
Windows to the north	< 5%

Specific points: No special points are required.

5.3.3 The concept houses for Oslo

Table 9. Factsheet building design characteristics for Oslo

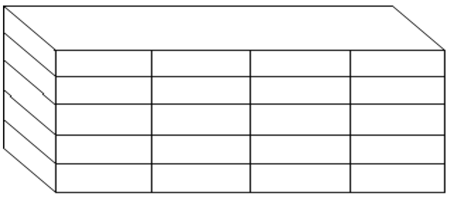
Single family house
(1 dwelling, 96 m^2 gross area)



Constraints:

U-value opaque envelope	< 0,10 W/m^{2}K
U-value glass	< 0,6 W/m^{2}K
U-value frame	< 1,0 W/m^{2}K
Heat recovery efficiency	> 85%
Air flow (country specific)	≈ 160 m^3/h
Windows to the south	30-60%
Windows to the east/west	< 15%
Windows to the north	< 5%

Appartment house
(20 dwellings, 2453 m^2 gross area)



Constraints:

U-value opaque envelope	< 0,12 W/m^{2}K
U-value glass	< 0,6 W/m^{2}K
U-value frame	< 1,0 W/m^{2}K
Heat recovery efficiency	> 80%
Air flow (country specific)	≈ 3350 m^3/h
Windows to the south	30-60%
Windows to the east/west	< 15%
Windows to the north	< 5%

Specific points:

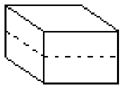
Big climatically differences from Oslo to Tromsø.

Be aware of the high air change during winter.
→ Heat recovery with humidity transfer is recommended

5.3.4 The concept houses for Tallinn

Table 10. Factsheet building design characteristics for Tallinn

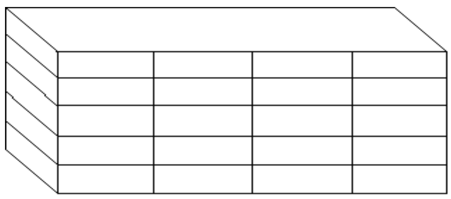
Single family house
(1 dwelling, 96 m^2 gross area)



Constraints:

U-value opaque envelope	< 0,10 W/m^2K
U-value glass	< 0,5 W/m^2K
U-value frame	< 1,0 W/m^2K
Heat recovery efficiency	> 85%
Air flow (country specific)	≈ 200 m^3/h
Windows to the south	40-60%
Windows to the east/west	< 20%
Windows to the north	< 5%

Appartment house
(20 dwellings, 2453 m^2 gross area)



Constraints:

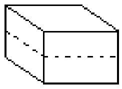
U-value opaque envelope	< 0,11 W/m^2K
U-value glass	< 0,7 W/m^2K
U-value frame	< 1,0 W/m^2K
Heat recovery efficiency	> 80%
Air flow (country specific)	≈ 3000 m^3/h
Windows to the south	40-60%
Windows to the east/west	< 20%
Windows to the north	< 5%

Specific points: Be aware of the high air change during winter. → Heat recovery with humidity transfer is recommended

5.3.5 The concept houses for Vilnius

Table 11. Factsheet building design characteristics for Vilnius

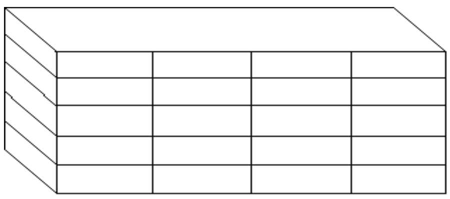
Single family house
(1 dwelling, 96 m^2 gross area)



Constraints:

U-value opaque envelope	< 0,10 W/m^2K
U-value glass	< 0,5 W/m^2K
U-value frame	< 1,0 W/m^2K
Heat recovery efficiency	> 85%
Air flow (country specific)	≈ 120 m^3/h
Windows to the south	40-60%
Windows to the east/west	< 20%
Windows to the north	< 5%

Appartment house
(20 dwellings, 2453 m^2 gross area)



Constraints:

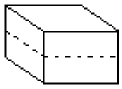
U-value opaque envelope	< 0,11 W/m^2K
U-value glass	< 0,7 W/m^2K
U-value frame	< 1,0 W/m^2K
Heat recovery efficiency	> 80%
Air flow (country specific)	≈ 2400 m^3/h
Windows to the south	40-60%
Windows to the east/west	< 20%
Windows to the north	< 5%

Specific points: No special points are required.

5.3.6 The concept houses for Riga

Table 12. Factsheet building design characteristics for Riga

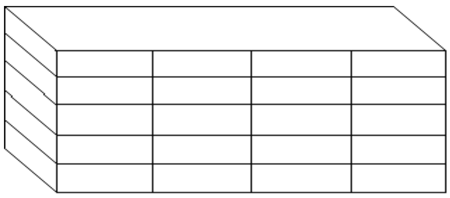
Single family house
(1 dwelling, 96 m^2 gross area)



Constraints:

U-value opaque envelope	< 0,10 W/m^2K
U-value glass	< 0,5 W/m^2K
U-value frame	< 1,0 W/m^2K
Heat recovery efficiency	> 85%
Air flow (country specific)	≈ 120 m^3/h
Windows to the south	40-60%
Windows to the east/west	< 20%
Windows to the north	< 5%

Appartment house
(20 dwellings, 2453 m^2 gross area)



Constraints:

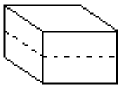
U-value opaque envelope	< 0,12 W/m^2K
U-value glass	< 0,7 W/m^2K
U-value frame	< 1,0 W/m^2K
Heat recovery efficiency	> 80%
Air flow (country specific)	≈ 2400 m^3/h
Windows to the south	40-60%
Windows to the east/west	< 20%
Windows to the north	< 5%

Specific points: No special points are required.

5.3.7 The concept houses for Warzaw

Table 13. Factsheet building design characteristics for Warzaw

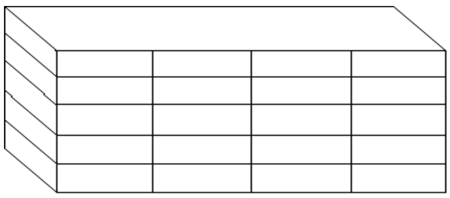
Single family house
(1 dwelling, 96 m^2 gross area)



Constraints:

U-value opaque envelope	< 0,11 W/m^2K
U-value glass	< 0,6 W/m^2K
U-value frame	< 1,0 W/m^2K
Heat recovery efficiency	> 85%
Air flow (country specific)	≈ 120 m^3/h
Windows to the south	40-60%
Windows to the east/west	< 20%
Windows to the north	< 5%

Appartment house
(20 dwellings, 2453 m^2 gross area)



Constraints:

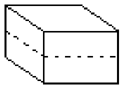
U-value opaque envelope	< 0,13 W/m^2K
U-value glass	< 0,7 W/m^2K
U-value frame	< 1,0 W/m^2K
Heat recovery efficiency	> 80%
Air flow (country specific)	≈ 2700 m^3/h
Windows to the south	40-60%
Windows to the east/west	< 20%
Windows to the north	< 5%

Specific points: No special points are required.

5.3.8 The concept houses for Copenhagen

Table 14. Factsheet building design characteristics for Copenhagen

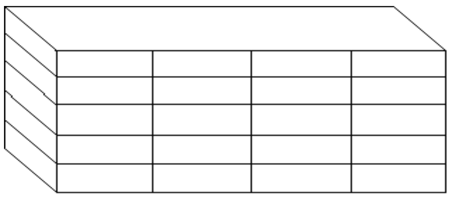
Single family house
(1 dwelling, 96 m^2 gross area)



Constraints:

U-value opaque envelope	< 0,12 W/m^2K
U-value glass	< 0,7 W/m^2K
U-value frame	< 1,0 W/m^2K
Heat recovery efficiency	> 85%
Air flow (country specific)	≈ 120 m^3/h
Windows to the south	40-60%
Windows to the east/west	< 20%
Windows to the north	< 5%

Appartment house
(20 dwellings, 2453 m^2 gross area)



Constraints:

U-value opaque envelope	< 0,16 W/m^2K
U-value glass	< 0,8 W/m^2K
U-value frame	< 1,0 W/m^2K
Heat recovery efficiency	> 80%
Air flow (country specific)	≈ 2400 m^3/h
Windows to the south	40-60%
Windows to the east/west	< 20%
Windows to the north	< 5%

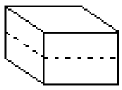
Specific points: Be aware of the high air change during winter. → Heat recovery with humidity transfer is recommended

5.3.9 Summary

In Table 14 the requirements for each climate has been summarised. Remember that the U-values are maximum values for the given building meaning that in some climates the U-value of the opaque building envelope must be *below* 0,08 W/m²/K.

Table 15. Factsheet building design characteristics for Copenhagen

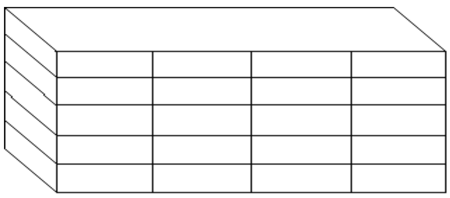
Single family house
(1 dwelling, 96 m^2 gross area)



Requirements:

U-value opaque envelope	0,08-0,12 W/m^2K
U-value glass	0,5-0,7 W/m^2K
U-value frame	1,0 W/m^2K
Heat recovery efficiency	> 85%
Windows to the south	30-60%
Windows to the east/west	10-20%
Windows to the north	5%

Appartment house
(20 dwellings, 2453 m^2 gross area)



Constraints:

U-value opaque envelope	0,10-0,16 W/m^2K
U-value glass	< 0,8 W/m^2K
U-value frame	< 1,0 W/m^2K
Heat recovery efficiency	> 80%
Windows to the south	40-60%
Windows to the east/west	10-20%
Windows to the north	< 5%

Specific points:	Be aware of the high air change during winter. → Heat recovery with humidity transfer is recommended

6 CONCLUSIONS

6.1 Contribution to overall picture

This deliverable finishes and completes the work done in WP2, which resulted in 3 deliverables:

D2. Application of the local criteria/standards and their differences for very low-energy and low energy houses in the participating countries

D3. Principles of low-energy houses applicable in the participating countries and their applicability throughout the EU

D4. Energy-demand levels and corresponding residential concept houses and the specific challenges of very low-energy houses in colder climates

In D2 information about the existing building regulations and very low energy criteria in use in eight North European countries were collected and compared *qualitatively*.

In D3, the main principles for very low energy building design were collected and compiled to meet the specific demands given by the lower temperature and less sun radiation in the winter time in the North Europe.

In D4, the comparison of the existing building regulations and very low energy criteria was performed *quantitative*: The compiled design rules from D3 were merged together with different approaches to meet very low energy consumption according to different criteria.

The focus was in the space heating demand. Nevertheless, also total energy use was calculated and compared when relevant for the different regulations and criteria.

6.2 Relation to the state-of-the-art and progress beyond it

The concrete calculation tasks in this deliverable on a single family house and an apartment house made it possible to compare all existing building regulations – both the criteria and the calculation tools used to verify the criteria – in 8 North European countries. These results are unique and give valuable input to any political or technical discussion.

The combination of the compiled design guidelines depending on the climatic conditions for the very low energy buildings in the colder climates and the concrete calculations with different calculation tools with different assumptions is a good starting point for any further work for realization of very energy efficient buildings in all Europe.

6.3 Impacts to other WPs

The concept houses in this report were defined purely on the technical basis: Calculation of heat losses and gains as a function of weather data and the physical layout of the building. Other work packages take up the life cycle analysis and costs (WP3), which barriers exists and how to remove these barriers for the increased market penetration of the very low energy houses in the North European countries (WP4 and WP5).

7 APPENDICES

7.1 Concept houses

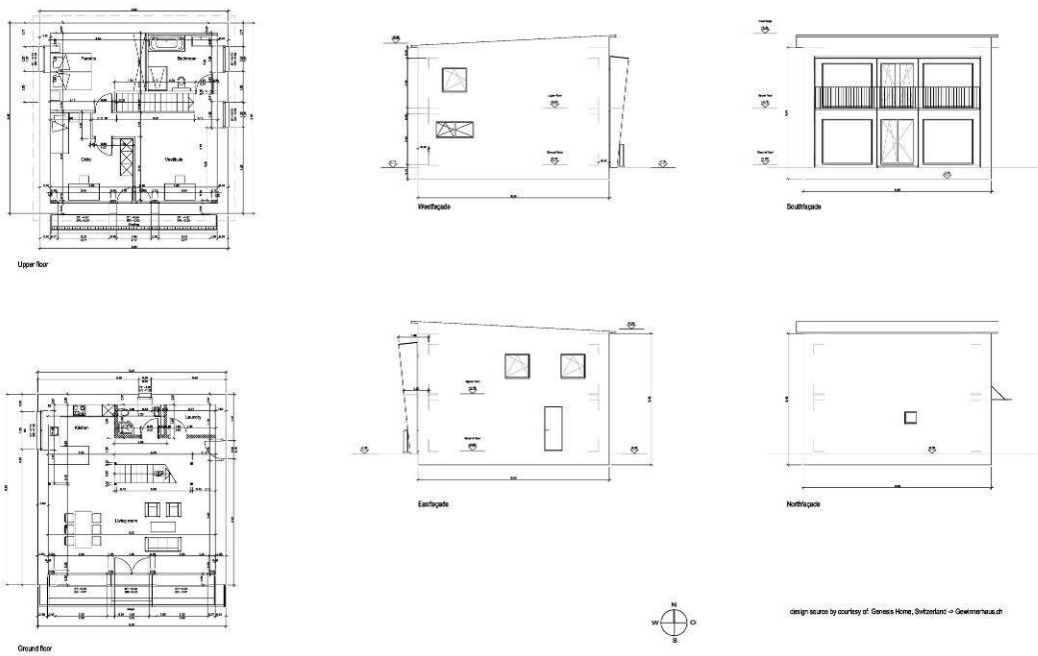
The both concept buildings are based on existing buildings in Switzerland that were build to be very energy efficient buildings. For the calculations in this NorthPass project the glass areas were optimised and the basement level was not included.

7.1.1 Single family house

Source:
GenesisHome AG, Obere Strasse 133, CH-4316 Hellikon, Phone: +41 61 871 03 84, www.genesishome.ch

Building:
concept house, Gewinnerhaus.ch

Drawings (in the appendix no scale):



7.1.2 Apartment house

Source:
BARBOS, St. Klara-Rain 1, CH-6370 Stans, Phone: +41 41 611 12 02, www.barbos.ch

Building:
Im Wechselacher 19, CH-6370 Stans

Drawings (in the appendix no scale):