EuroSun 2010 – THE DEVELOPMENT OF PASSIVHOUSE CRITERIA FOR NON-RESIDENTIAL BUILDINGS IN NORWAY

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Abstract

The passive house (PH) concept is a successful measure to reduce energy use in buildings. It has been applied in many projects in Europe, especially in Germany and Austria. In Norway the attempt was made to describe the PH concept in a new building norm [4]. Dynamic building simulation software has been applied and PH criteria for non-residential building types were developed. The PH concept is introduced and discussed in relation to the existing building codes. Here, detailed criteria for maximum installed power and annual energy use for heating, cooling, lighting, ventilation, and equipment are specified. Also, CO_2 emissions related to the energy used are introduced, and their implications for building and energy services are introduced. Planning according to described criteria can lead to cost effective buildings and energy solutions with simplified building services and minimized energy use and emissions [2]. If a drastic reduction in CO_2 emissions shall be reached, it is essential to integrate energy supply systems into the building design. For CO_2 neutral building design new solutions need to be developed.

1. Introduction

Energy efficiency of the Norwegian building stock has been pointed out as a major strategy in cutting greenhouse gas (GHG) emissions according to the Kyoto-protocol [1]. The energy consumption of existing office building is rising over the past decade (www.enova.no). The passive house (PH) concept is a successful measure to reduce energy use in buildings. It has been applied in many projects in Europe, especially in Germany and Austria. In Norway the attempt was made to describe the PH concept in a new building norm [4]. There were a number of reasons for the development of PH criteria for non-residential building types:

- There was a demand for passive house criteria for different energy efficiency financial schemes.
- Criteria and experiences from Germany and Austria show many similarities but needed to be adjusted to the Norwegian building regulations [3].
- New Norwegian Standard NS3700 for residences was under development [4].
- Swedish proposal for passive house criteria was under development.
- The use of the expression passive house needed to be clarified.

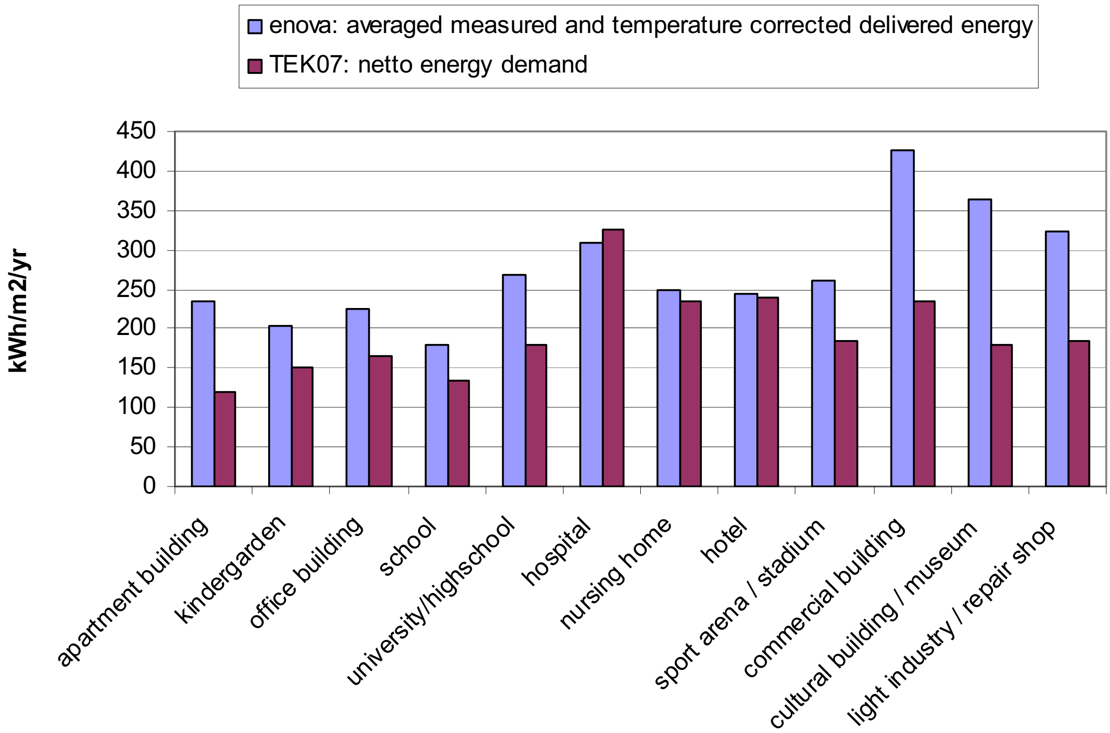

Fig. 1. Measured and temperature corrected delivered energy and net energy demand according to TEK07 in different building types.

2. Objectives

The PH concept is introduced and discussed in relation to the existing building codes. Here, detailed criteria for maximum installed power and annual energy use for heating, cooling, lighting, ventilation, and equipment are specified. Passive house criteria for different building types (other than residential) are needed. These have been developed. Missing CO_2 emissions factors related to the energy used are discussed, and their implications for zero emission buildings are discussed.

3. Method

This paper describes the holistic approach of accounting for all parts of a building that use energy, i.e. heating, warm water, cooling, lighting, ventilation, and equipment. The Norwegian building codes have recently been revised and the requirements on insulation levels, air tightness, and ventilation systems have become stricter [5].Dynamic building simulation software has been applied and PH criteria were developed. Here, detailed criteria for maximum installed power and annual energy use for heating, cooling, lighting, ventilation, and equipment are specified. Also, CO_2 emissions related to the energy used are introduced, and their implications for building and energy services are discussed.

The following criteria were specified:
• Average air volume (inside and outside operating hours)
• Internal loads (lighting, equipment, and personnel)

• Annual energy demand for heating and cooling
• Overall heat losses
• CO_2 emissions
• Minimum requirements

The differences to national building regulations have been discussed.

3.1. Minimum requirements

The calculation method has been revised in Norway in 2007 [3]. In addition, building regulations were revised [5] introducing two ways to fulfill the energy requirements for a building.

- Energy measure method (Energitiltak)
- Energy frame method (Energirammer)

The so-called Energy measure method (Energitiltak) has to set requirements for certain building elements and installations. For code compliance these requirements have to be fulfilled and documented. Alternatively, if the net energy demand for the building, calculated according to the methodology established in the new Norwegian Standard NS3031 (2007), is within the energy frame for the building's category, the regulations are also satisfied [3]. Here, a holistic approach was chosen, accounting for all energy a building needs. Since the frame is based on net specific energy demand per year, the efficiencies of the energy systems are not taken into account. This means that for example the coefficient of performance of a highly efficient mechanical cooling system is not rewarded.

Table 1. Minimum requirements.

characteristics	**TEK07**	**passive house**
U- value walls	≤ 0.18 W/(m²·K)	≤ 0.15 W/(m²·K)
U- value floor	≤ 0.15 W/(m²·K)	≤ 0.15 W/(m²·K)
U- value roof	≤ 0.13 W/(m²·K)	≤ 0.13 W/(m²·K)
U- value windows[a]	≤ 1.20 W/(m²·K)	≤ 0.80 W/(m²·K)
U- value doors	≤ 1.20 W/(m²·K)	≤ 0.80 W/(m²·K)
Normalized thermal bridge value, Ψ'	≤ 0.03 W/(m²·K)	≤ 0.03 W/(m²·K)
System efficiency heat recovery, ηT[b]	≥ 70 %	≥ 80 %
SFP-factor ventilation system	≤ 2.5 kW/(m³/s)	≤ 1.5 kW/(m³/s)
Air leakage at 50 Pa, n50	$\leq 2.50\ h^{-1}$	$\leq 0.60\ h^{-1}$

[a] incl. frames

[b] annual mean temperature efficiency

Passive measures that reduce the net cooling demand will contribute to satisfy the energy frame which has led to a renewed interest in utilizing passive measures to decrease the total energy use in all building types. However, there are still minimum requirements concerning the U-values and air tightness of the building envelope which help to maintain a good insulation standard. These are listed Table 1 above [5].

3.2. Average air volume and internal loads

The holistic approach mentioned above led to a new evaluation of internal loads and minimum values for ventilation.

Table 2. Internal loads.

building type	**lighting**	**equipment**	**occupants**	**internal gains (average)**
	W/m²	**W/m²**	**W/m²**	**W/m²**
kindergarten	6	2	6	4.2
office building	5	6	4	5.4
school	6	4	12	5.4
university/high school	6	5	6	6.1
hospital	5	8	2	10.7
nursing home	5	4	3	9.0
hotel	5	1	2	6.0
sport arena / stadium	6	1	10	5.0
commercial building	11	1	7	8.1
cultural building / museum	6	1	3.2	3.3
light industry / repair shop	6	10	2	4.8

3.3. Annual energy demand for heating and cooling

In residential buildings annual heating is typically restricted to 15 kWh/(m^{2}a) and mechanical cooling is avoided. In other building types this concept had to be evaluated since some building types require some mechanical cooling.

3.4. Overall heat losses

Normalized overall heat loss is defined by heat losses through the building envelope, heat losses through ventilation and infiltration and calculated for heated floor area.

3.5. CO_2 emissions

In order to evaluate the CO_2 emissions of a building from its operation CO_2 factors of the delivered energy are needed. Proposed CO_2 factors are shown in Table 3. This requires in addition the adjustment of net energy demand to delivered energy. Here, the efficiency of a heating and/or cooling system needed to be considered [3].

Table 3. CO_2 factors for different energy carriers.

Energy carrier	CO_2-factor
	(g CO_{2eq}/kWh)
Biofuel	14
District heating	231
Gas (fossil)	211
Oil	284
Electricity	395

4. Results

4.1. Average air volume

Table 4 gives the average airflow requirements during and outside operation. It can be seen that airflow during operation ranges between 6 (kindergarten, offices, hotels, and sport arenas) and 12 $m^3/(hm^2)$ (commercial buildings).

Table 4. Average airflow requirements.

building type	average airflow	
	during operation	outside operation
	$m^3/(hm^2)$	$m^3/(hm^2)$
kindergarten	6	1
office building	6	1
school	8	1
university/high school	7	1
hospital	10	3
nursing home	7	1
hotel	6	1
sport arena / stadium	6	1
commercial building	12	1
cultural building / museum	7	0
light industry / repair shop	7	0

4.2. Maximum allowed requirements

Table 5 shows the maximum allowed energy demand, heat loss factor, and CO_2 emissions. It can be seen that maximum heating demand ranges between 15 (offices, schools, universities, and nursing homes) and 25 kWh/(m²a) (kindergarten, sport arena, cultural building, and light industry). Maximum cooling demand ranges between 0 (kindergarten and schools) and 20 kWh/(m²a) (hospitals and commercial buildings).

Heat losses range between 0.5 (offices, schools, universities, and cultural buildings) and 0.75 W/(m2·K) (hospitals).

Maximum allowed CO_2 emissions range between 20 (kindergarten and schools) and 60 kg/(m2·a) (hospitals).

Table 5. Maximum allowed energy demand, heat loss factor, and CO2 emissions.

building type	**annual energy demand**		**Heat loss, H''**	**CO_2-emissions, m''**
	Heating	**Cooling**		
	kWh/(m²a)	**kWh/(m²a)**	**W/(m^2·K)**	**kg/(m^2·a)**
kindergarten	25	0	0.6	20
office building	15	10	0.5	25
school	15	0	0.5	20
university/high school	15	10	0.5	30
hospital	20	20	0.75	60
nursing home	15	10	0.65	45
hotel	20	10	0.65	40
sport arena / stadium	25	10	0.7	30
commercial building	20	20	0.65	40
cultural building / museum	25	10	0.5	25
light industry / repair shop	25	10	0.55	25

5. Conclusion

The PH concept is a good starting point on the conceptual path to minimizing building energy use and CO_2 emissions. The newly introduced PH criteria for non-residential buildings show small but important differences in the minimum requirements. Especially improved requirements for air tightness needs a careful design and detailed planning. Here, the building sector needs more support and information on predefined construction solutions.

Maximum allowable heat loss factors will ensure a building construction quality which is a prerequisite to be able to build buildings with minimum CO2 emissions. Thus, planning according to described criteria can lead to cost effective buildings and energy solutions with simplified building services and minimized energy use and emissions. In the non-residential sector with more complex building services, and with an increase in delivered energy there is an increased need for such criteria. In order to minimize energy use and CO_2 emissions it seems appropriate to further link decisions on suitable energy supply systems with regard to related CO_2 emissions.

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