MEMORANDUM

DANISH BUILDING RESEARCH INSTITUTE
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ENERGY EFFICIENCY, INDOOR CLIMATE AND SUSTAINABILITY OF BUILDINGS

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ENERGY RENOVATION

Long-Term Renovation Strategy

Aim

The aim of this project is to provide a calculation of the anticipated scope of energy renovated buildings in 2020. The calculation will be used to fulfil Article 1a of the long-term renovation strategy (LTRS) that Denmark must submit in March 2020 as part of the compliance with EU Directive 2018/844 (Energy Performance of Buildings Directive).

Regarding LTRS (Long-Term Renovation Strategy), Commission Recommendation (EU) 2019/786 of 8 May 2019 on building renovation recommends that Member States group the depth of the energy renovation of a building into 'light', 'medium', and 'deep'. It is in turn proposed that this be defined in relation to the primary energy saving, which for light is: <30%, medium: 30-60% and deep: >60%. However, this is not a requirement in the EPBD.

Method

The present analysis of the scope of energy renovated buildings in Denmark is based on data from the energy rating scheme from the period between September 2006 and June 2019.
The key data extracted for this analysis is:

- Energy rating
- Building use
- Year of construction
- Heat requirement (calculated) [kWh/m2]
- Rating date
- PV system
- U_{av}-values for windows
- U_{av}-values for lofts

The heat requirement of buildings is calculated normatively using the energy rating with an indoor temperature of 20°C and includes hot water and pipe losses, but excludes conversion and supply losses. Based on the heat requirement data, the buildings in the analysis are grouped according to the magnitude of the calculated heat requirement corresponding to the level of detail in the energy rating scale (see Table 1) with the deduction of a typical electricity requirement for building operation of 5 kWh/m2 (corresponding to approximately 2 kWh/m2 multiplied by the primary energy factor for electricity of 2.5).

TABLE 1. GROUPING BY RENOVATION DEPTH CALCULATED ACCORDING TO ENERGY RATING AND HEAT REQUIREMENT.

Renovation depth	Energy rating	Heat requirement
No renovation	F or G	> 235
Light renovation	E or D	135 - 235
Medium renovation	C or B	60 - 135
Deep renovation	A*	< 60

A* is the grouping of the ratings A1, A2, A2010, A2015 and A2020

If the calculation of energy renovated buildings is based according to the energy rating (A*, B ... G), it must be taken into account that the energy rating for many buildings may be affected by a PV system and therefore does not reflect the actual energy renovation of the building envelope.

As a supplement, and to better understand the level and development of energy renovations, an analysis has also been prepared of the energy renovation depth for the retrospective insulation of roof/loft structures and window replacements for the various types of building use and construction periods.

It should be noted that energy ratings are often assigned in connection with the sale of a property for single-family houses. It can be anticipated that, following a sale, certain properties may undergo a major or minor renovation such as the replacement of windows or the installation of a new heating system. The method in connection with the use of data from the energy rating register must therefore be anticipated as giving a conservative estimate of the actual renovation depth.

Building use (types)

Five general building use types[1] have been used, calculated according to use codes in the Central Register of Buildings and Dwellings (BBR).

- Farmhouses (code 110)
- Single-family houses (code 120)
- Terraced houses (codes 130, 131, 132)
- Apartment buildings, etc. (140 - 190)
- Offices, trade and services, etc. (Codes 310 - 390)
- Institutions (Codes 410 - 490)

Delimitation by year of construction

The first heat insulation requirements for structures were introduced in the Building Regulations in 1961, but were relatively lenient. Heat insulation requirements were tightened considerably in the Building Regulations from 1977, taking effect from 1 February 1979. See Table 2.

[1] This is the same division as used in 'Heat conservation in existing buildings', SBi: 2017:06

TABLE 2. MINIMUM HEAT INSULATION REQUIREMENTS FOR OLDER BUILDINGS (U-VALUE REQUIREMENTS)

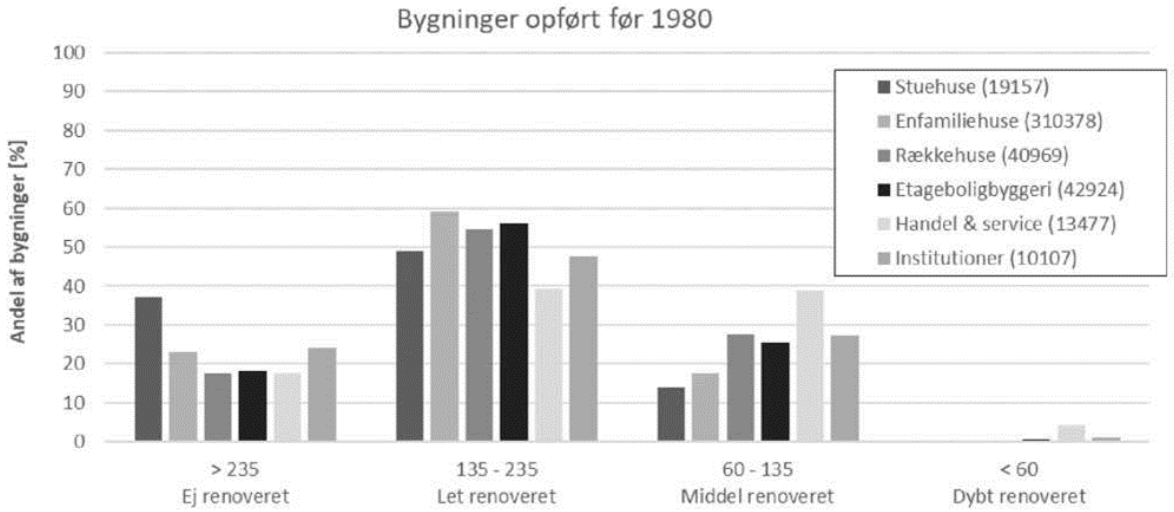
Building element	BR 61	BR 67	BR 72	BR 77 (to 1.2-79)	BR 82	BR-S 85	BRS 85 1.4.85-1.4.86	BR 95 and BR-S 98	BR 2008	BR 2010 and BR 2015
Exterior walls > 100 kg/m2 + against the ground	1.1	1.1	1	0.4	0.4	0.4	0.40-0.35	0.3	0.4	0.3
Exterior walls < 100 kg/m2	0.5	0.5	0.6	0.3	0.3	0.3	0.3	0.2	0.4	0.3
Basement exterior walls	-	-	-	-	-	0.4	0.4	0.3	0.4	0.3
Partition walls - unheated rooms	1.7	1.7	2	0.5	0.5	0.5	0.5	0.4	0.5	0.4
Slab	0.4	0.4	0.45	0.3	0.3	0.3	0.3	0.2	0.3	0.2
Slab with underfloor heating	-	-	-	-	-	-	-	0.15	0.3	0.2
Floor against ventilated crawlspace	0.5	0.5	0.6	0.6	0.3	0.3	0.3	0.2	0.3	0.2
Floor structures above/facing open air	0.4	0.4	-	0.45	0.2	-	-	0.2	0.3	0.2
Floor structures facing an unheated room	0.5	0.5	0.6	0.4	0.2	0.5	-	0.4	0.4	0.4
Loft and roof structures	0.4	0.4	0.45	0.2	0.2	0.2	0.2	0.15	0.25	0.2
Flat roofs / sloping walls	0.4	0.4	-	-	-	-	-	0.2	0.25	0.2
External doors, gateways and hatches	-	-	-	2	2	2	2	1.8	2	1.8
Windows, etc.		-	2.9	2.9	2.9	2.9	2.9	1.8	2	1.8

Source: HANDBOOK FOR ENERGY CONSULTANTS 2019 (HÅNDBOG FOR ENERGIKONSULENTER 2019) (HTTP://WWW.HB-EMO.DK)

Based on the tightening of Building Regulations in BR77 with the supplement applicable from 1 February 1979, a decision has been made to analyse the level of renovation depth for buildings built before 1980, as these buildings are considered to have been built with a relatively limited level of heat insulation. Buildings built after 1980 are generally well insulated.

Results

The following results are based on data from around 437 000 buildings built before 1980 and energy rated during the period 2006-2019. The distribution of the calculated heat requirement for the buildings grouped according to use is shown in Figure 1.



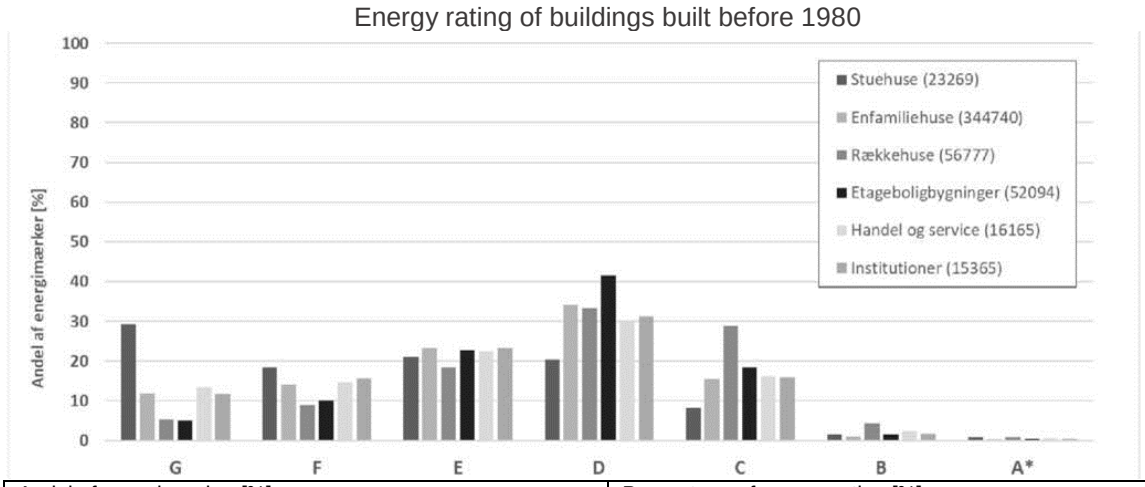
Bygninger opført før 1980	Buildings built before 1980
Andel af bygninger [%]	Proportion of buildings [%]
Stuehuse (19157)	Farmhouses (19 157)
Enfamiliehuse (310378)	Single-family houses (310 378)
Rækkehuse (40969)	Terraced houses (40 969)
Etageboligbyggeri (42924)	Apartment buildings (42 924)
Handel & service (13477)	Trade and services (13 477)
Institutioner (10107)	Institutions (10 107)
Ej renoveret	Not renovated
Let renoveret	Light renovation
Middel renoveret	Medium renovation
Dybt renoveret	Deep renovation

Heat requirement [kWh/m1]

FIGURE 1 DISTRIBUTION OF BUILDING STOCK BUILT BEFORE 1980 IN RELATION TO ENERGY RENOVATION DEPTH CALCULATED ACCORDING TO BUILDING USE AND CALCULATED HEAT REQUIREMENT.

It is generally considered that buildings built before 1980 and that have not yet been energy renovated will have a calculated heat requirement greater than 235 kWh/m^2. As can be seen in Figure 1 for example, around 22% of single-family houses have not yet been renovated and around 60% and 18% have been renovated to a level corresponding to the categories of *light* and medium respectively. In general, a very limited percentage of buildings can be categorised as having undergone deep energy renovation. A corresponding estimate has also been prepared for eight specific construction periods, see Annex 1.

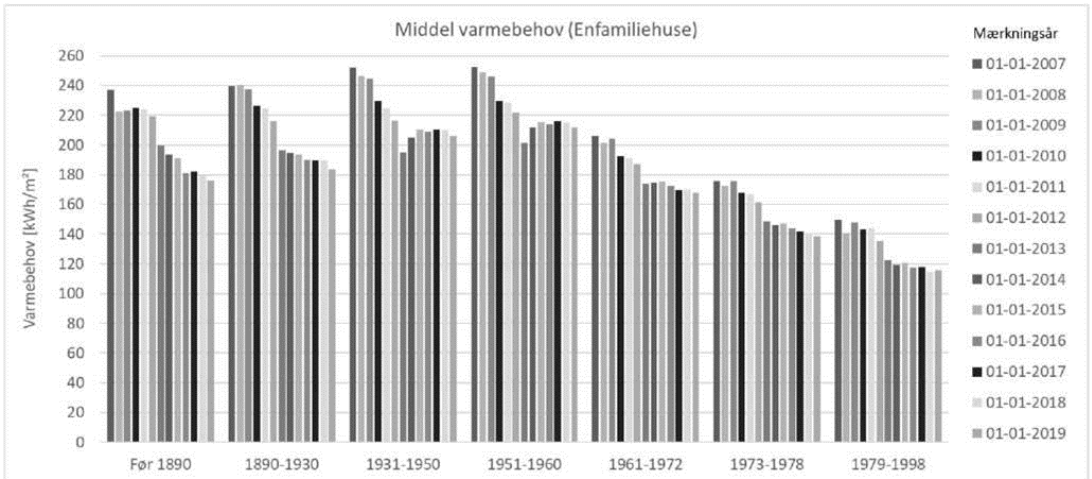
Figure 2 shows the building stock built before 1980 divided according to energy rating and grouped according to building use type. It must be noted in this comparison that many buildings have PV systems, which improves the energy rating.



Andel af energimærker [%]	Percentage of energy rating [%]
Stuehuse (23269)	Farmhouses (23 269)
Enfamiliehuse (344740)	Single-family houses (344 740)
Rækkehuse (56777)	Terraced houses (56 777)
Etageboligbygninger (52094)	Apartment buildings (52 094)
Handel og service (16165)	Trade and services (16 165)
Institutioner (15365)	Institutions (15 365)
Energimærke	Energy rating

FIGURE 2 Building stock built before 1980 divided according to energy rating. Including buildings with PV systems. A* covers A2010, A2015, A2020, A1, A2

Figure 3 shows the development in the calculated average heat requirement for single-family houses calculated according to construction period and energy rating year (the year the building was given an energy rating). This method indicates that the trend for single-family houses is a steady decline in the calculated heat demand.



Varmebehov [kWh/m^2]	Heat requirement [kWh/m^2]
Middel varmebehov (Enfamiliehuse)	Average heat requirement (Single-family house)
Mærkningsår	Year of rating
Før 1890	Pre-1890

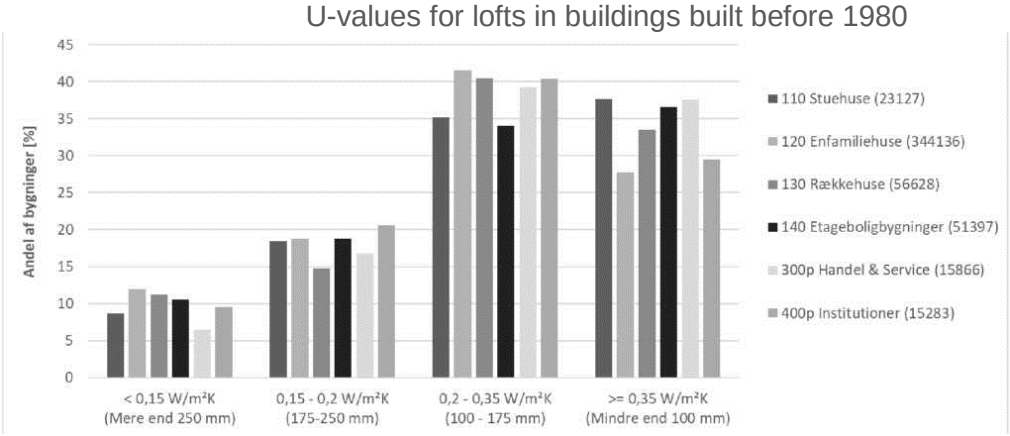
Construction period

FIGURE 3 The development in the calculated average heat requirement for single-family houses calculated according to construction period and energy rating year.

The results for the other building use types can be found in Annex 2.

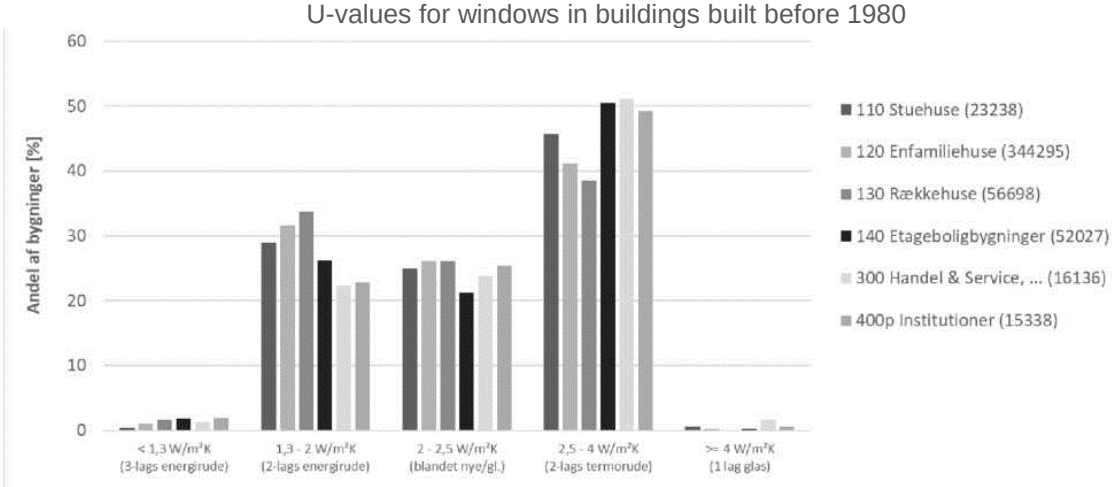
Loft insulation and window solutions

Retrospective insulation of the loft and window replacement are the measures often performed first in connection with energy renovation. The distribution of the level of loft insulation amongst the building stock is shown in Figure 4 for buildings built before 1980, calculated according to an area-weighted U-value for each specific building. Figure 5 correspondingly shows the distribution of window solutions amongst the building stock in relation to a calculated area-weighted U-value for each building.



Andel af bygninger [%]	Proportion of buildings [%]
110 Stuehuse (23127)	110 Farmhouses (23 127)
120 Enfamiliehuse (344136)	120 Single-family houses (344 136)
130 Rækkehuse (S662S)	130 Terraced houses (56 628)
140 Etageboligbygninger (51397)	140 Apartment buildings (51 397)
300p Handel & Service (15866)	300p Trade and services (15 866)
400p Institutioner (15283)	400p Institutions (15 283)
(Mere end 250 mm)	(More than 250 mm)
(Mindre end 100 mm)	(Less than 100 mm)

FIGURE 4 Distribution of buildings according to their area-weighted U-value [W/m²K] for loft/roof structures for buildings built before 1980. An approximate insulation level [mm] is given in brackets for the use of insulation with a lambda value of 0.037 W/mK.



110 Stuehuse(23238)	110 Farmhouses (23 238)
120 Enfamiliehuse (344295)	120 Single-family houses (344 295)
130 Rækkehuse (56698)	130 Terraced houses (56 698)
140 Etageboligbygninger (52027)	140 Apartment buildings (52 027)
300 Handel & Service,... (16136)	300 Trade and services, ... (16 136)
400p Institutioner (15338)	400p Institutions (15 338)
(3-lags energirude)	(Triple glazing)
(2-lags energirude)	(Double glazing)
(blandet nye/gl.)	(Mixed new/old)
(2-lags termorude)	(Double insulating glass unit)
(1 lag glas)	(Single glazed)

FIGURE 5 Distribution of buildings according to their area-weighted U-value [W/m2K] for window solutions for buildings built before 1980. Estimated glazing type is indicated in brackets.

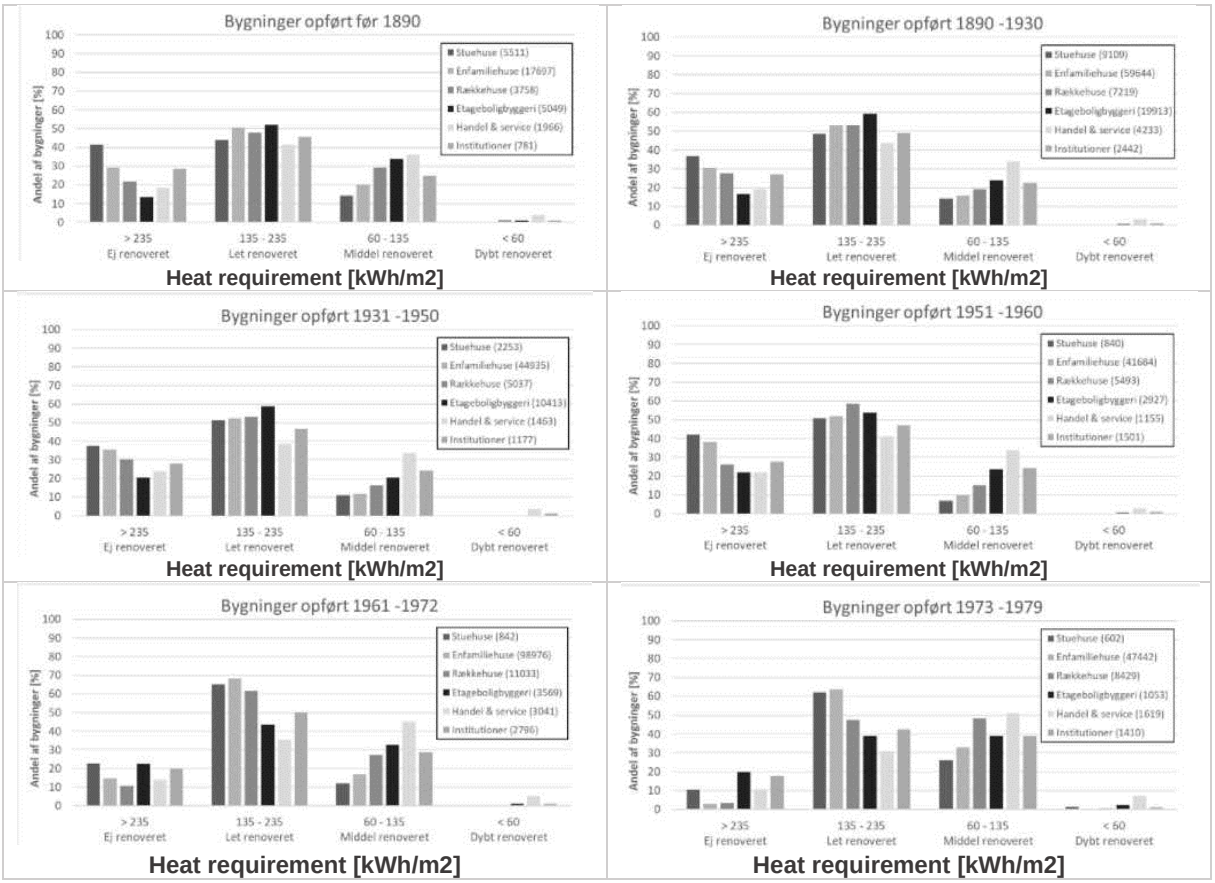
Summary

The energy renovation depth for the Danish building stock built before 1980 has been calculated in an analysis of data from the energy rating register as of June 2019. Overall, the results indicate that around 20% of the building stock has not yet been energy renovated, around 55-60% has undergone light energy renovation, around 20-25% has undergone medium energy renovation and deep energy renovation has only been performed to a very limited extent. There are however differences between the various building use types, see Figure 1.

A projection is sought for the anticipated calculation of energy renovation depth in 2020. The results above are however only based on data up to June 2019 (inclusive), but it is considered that the results would only change marginally if data for the period July-December 2019 were to be included.

Annex 1

The distribution of the calculated heat requirement for the buildings grouped according to size and calculated for specific construction periods is shown in Figure 6.



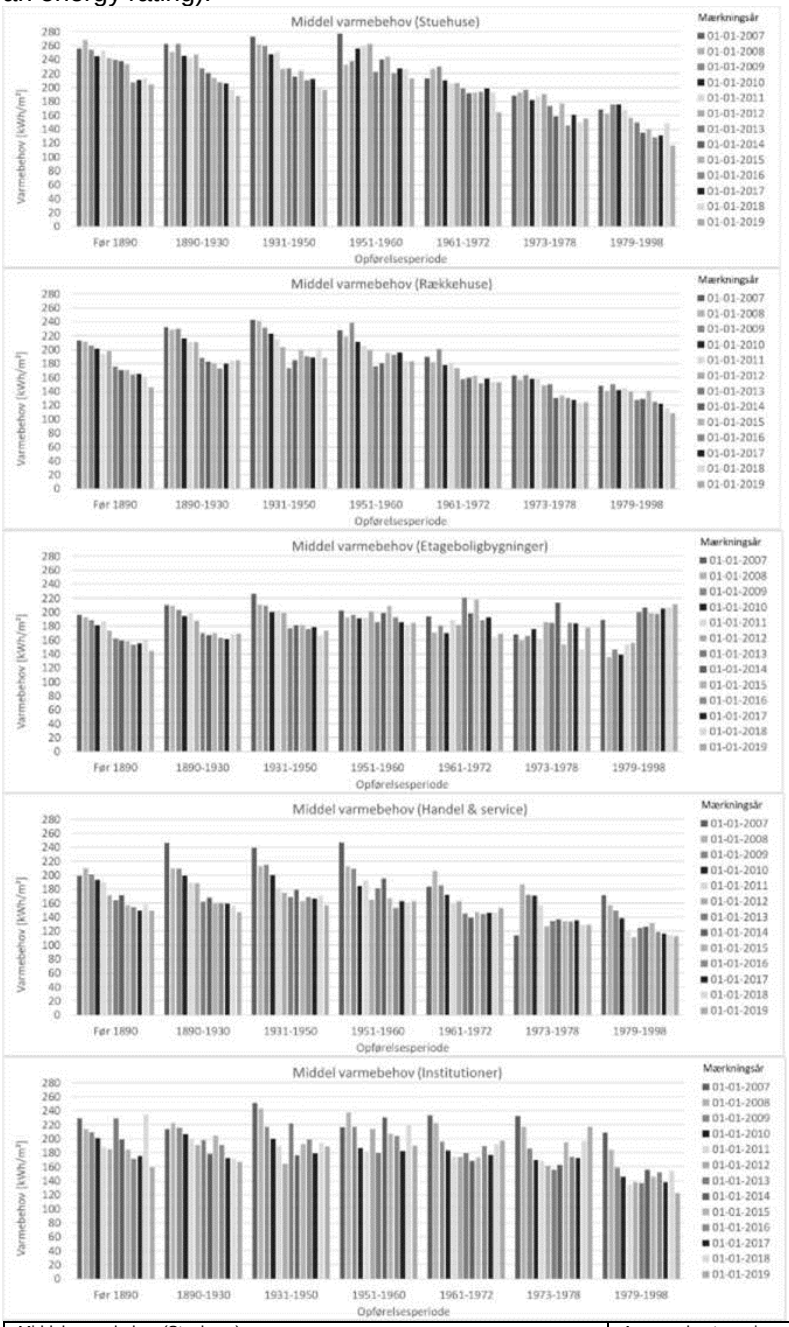
Andel af bygninger [%]	Proportion of buildings [%]
Bygninger opført før 1890	Buildings built before 1980
Stuehuse (5511)	Farmhouses (5 511)
Enfamiliehuse (17697)	Single-family houses (17 697)
Rækkehuse (3758]	Terraced houses (3 758)
Etageboligbyggeri (5049)	Apartment buildings (5 049)
Handel & service (1966)	Trade and services (1 966)
Institutioner (781)	Institutions (781)
Ej renoveret	Not renovated
Let renoveret	Light renovation
Middel renoveret	Medium renovation
Dybt renoveret	Deep renovation

FIGURE 6. CALCULATED HEAT REQUIREMENT OF BUILDINGS CALCULATED ACCORDING TO USE AND GROUPED ACCORDING TO ENERGY RENOVATION DEPTH.

Note: The proportion of 'medium renovations' represents a steadily increasing percentage for the period 1973-1979. This must be assessed based on the fact that there was an increasing tendency during this period for insulation to be added to new builds, even though the Building Regulations in force at the time were very lenient. The reason for the higher level of insulation is likely to be related to the energy crisis in 1973.

Annex 2

Trend in the calculated average heat requirement calculated according to construction period and energy rating year (the year the building was given an energy rating).



Middel varmebehov (Stuehuse)	Average heat requirement (Farmhouses)
Varmebehov [kWh/m^2]	Heat requirement [kWh/m^2]
Mærkningsår	Year of rating
Før 1890	Pre-1890
Opførelsesperiode	Construction period
Middel varmebehov (Rækkehuse)	Average heat requirement (Terraced houses)
Middel varmebehov (Etageboligbygninger)	Average heat requirement (Apartment buildings)
Middel varmebehov (Handel & service)	Average heat requirement (Trade and services)
Middel varmebehov (Institutioner)	Average heat requirement (Institutions)

FIGURE 7 Calculated average heat requirement calculated for each rating year