

Model Project 1 / Germany

**Data collection from energy audits
for residential buildings
granted by the climate protection fund
proKlima in Hanover**

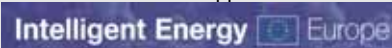
– Summary Report –

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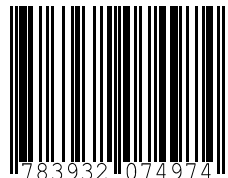
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1 Summary

Objectives of the DATAMINE Project

The starting point of DATAMINE is the fact that the actual state of the European building stock and the on-going retrofit processes are not very well known until now. This information gap can be seen as a great obstacle for taking well-tailored measures to reduce the buildings' energy consumption. The idea of DATAMINE is to use Energy Performance (EP) Certificates as a data source for monitoring. Given the great variety of buildings as well as certificate types in Europe and the very different status of national EPBD implementation a general monitoring system can only be implemented in the long run. Thus the objective of DATAMINE is to make basic experiences in data collection and analysis on a practical level and to draw conclusions for establishing harmonised monitoring systems.

For this purpose Model Projects are carried out in 12 EU member states. In each Model Project data collection and monitoring by use of EP Certificates is tested on a small scale. Each Model Project has an individual design, addressing different building utilisations and certification types as well as data collection methods and monitoring targets – depending on the focus of the involved key actors. Accordingly, each Model Project considers different national certification or data collection activities.

The experiences and evaluations which were made in the German Model Project are described in this report (which is also available in an extended version in German language). Similar reports exist for the other DATAMINE Model Projects showing the individual concepts and results. A survey of the most relevant results from all Model Projects is given in the DATAMINE Synthesis Report SR2 "Data Collection from Energy Certificates – Experiences and Analysis".

Status of introduction of Energy Performance Certificates in Germany

Since the year 2002 Energy Performance Certificates basing on the primary energy demand for heating and hot water are issued for new buildings in Germany. For existing buildings new regulations came into force in October 2007. In case of renting or sale EP Certificates have to be available: for residential buildings starting from the period July 2008 to January 2009 (depending on building size and age), for non-residential buildings starting from July 2009 (including the presentation in a prominent place for public buildings).

For all existing buildings there is a free choice between asset rating and operational rating – except for small residential buildings (1 to 4 apartments) built before 1977 where only asset rating is allowed.

Fig. 1: Status of Energy Performance Certificate introduction in Germany

Regulations are fixed by government		yes	
Coming into force		October 2007	
Availability of EP Certificates*	residential buildings	Jul 2008 / Oct 2008 / Jan 2009**	
	non-residential buildings	July 2009	
		Asset Rating	Operational Rating
Residential buildings			
new		yes	no
existing			
small buildings (1 to 4 apartments)	constructed before 1977	yes	no
	constructed 1977 or later	yes	yes
large buildings (5 or more apartments)		yes	yes
Non-residential Buildings			
new		yes	no
existing		yes	yes

*) for existing buildings in case of renting or sale (for new buildings already since 2002)

***) depending on building age and building size

The DATAMINE Model Project in Germany

The German DATAMINE model project aimed at the analysis of the energy saving support programme for existing buildings proKlima-Altbau which is run in the region of Hannover. The main objective was the calculation of the carbon dioxide emission reduction which could be achieved by the supported measures. Two main sources with energy certificate data were used during the project:

- Detailed data from 261 energy certificates were provided by Stadtwerke Hannover (the local energy supply company), who also act as energy consultants.
- Simplified data sets from 254 energy certificates. Those datasets, which include only a few data, are collected by proKlima for every supported building.

The 261 datasets from Stadtwerke Hannover provided information of the state of the buildings before modernisation but it was not sure if the distribution of building types (single- or multi-family-buildings) and heat sytem types (especially: type of the used energy carrier) was the same as for the whole support programme, because e.g. the building owners who ordered energy certificates by Stadtwerke Hannover might be a special section of all supported building owners. So the calculation of the percentage share of building types and heating system types in the support programme was carried out by analysing the 254 simplified datasets which are more probably a random sample of the buildings which were supported in the programme.

In the recent years the energy certificates of proKlima Hannover were issued according to a scheme which was elaborated by the German Energy Agency (dena) beeing very similar to the official scheme which was introduced in October 2007 .

Main results of the data evaluation

Fig. 2: General statistics of the analysed datasets

Number of collected datasets		515	
Certificate types		Utilisation types	
whole buildings	515	residential buildings	515
building parts	-	offices	-
apartments	-	education	-
Rating types		Buildings constructed ...	
only asset rating	257	1900 or earlier	16
only operational rating	-	from 1901 to 1940	127
both asset and oper. rating	258	from 1941 to 1980	154
Considered energy uses		Buildings constructed ...	
heating	515	from 1981 to 2000	38
hot water	515	since 2001	-
cooling / air conditioning	-		
lighting	-		
others	-		

(analysed data: total 515 data sets: 261 energy certificates with detailed data, further 254 simplified energy certificate datasets, collected and also transferred to the harmonised DATAMINE data structure but not analysed: 2885 simplified datasets from a preceding period)

A detailed overview of the state of the funded building stock before modernisation was carried out by analysing the 261 energy certificates of Stadtwerke Hannover. As examples the average U-values of the walls (depending on the age of the building), the frequency of the heat generator types and of the calculated primary energy demand (by energy carrier) are depicted here.

Fig. 3: Mean U-Value of walls, depending on building construction cycle

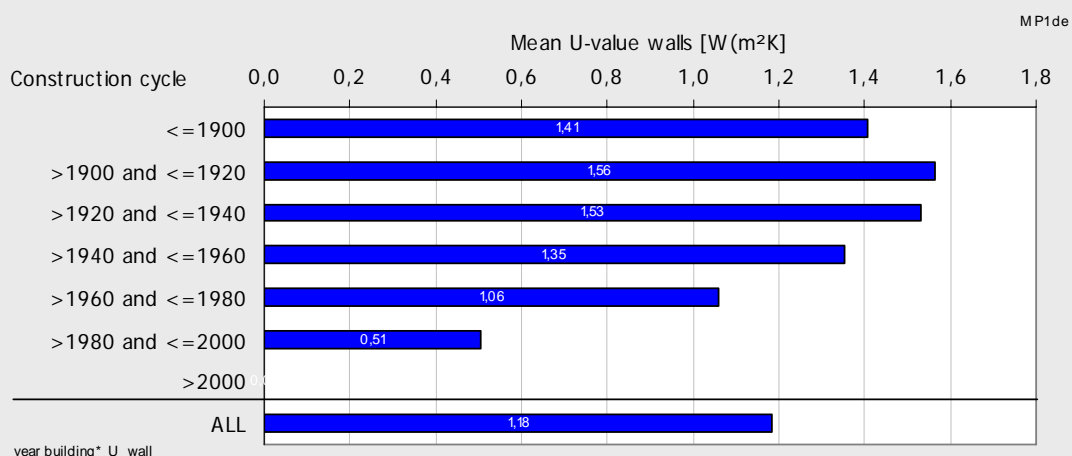


Fig. 4: Frequency of heat generator types for combustion of fuels + respective energy carriers

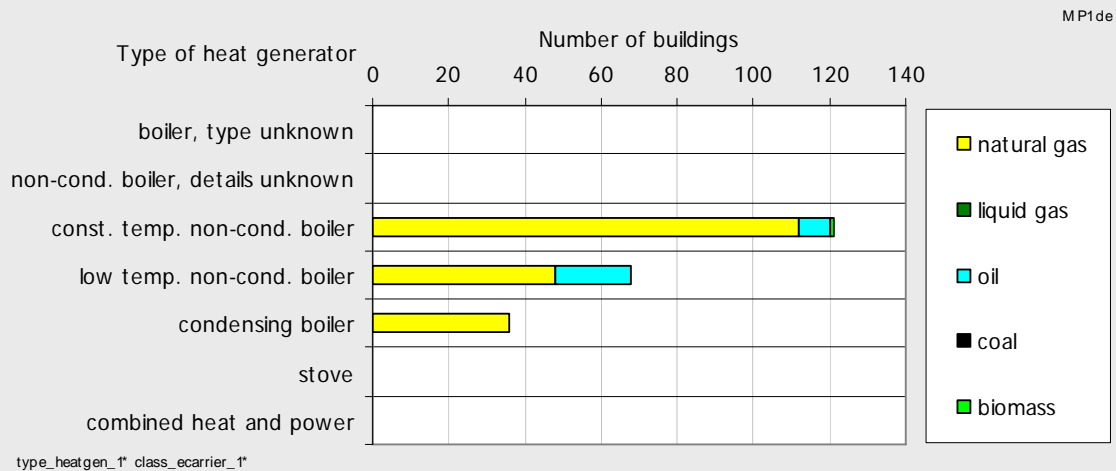
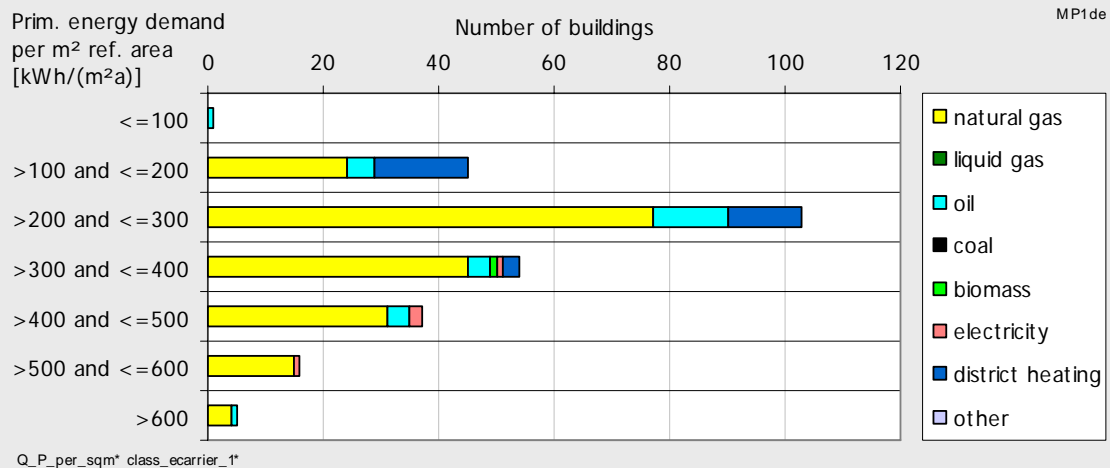


Fig. 5: Frequency distribution of the primary energy demand (depending on energy carriers used by the main heat generator)



The aim of calculating the carbon dioxide reduction was achieved in three steps:

- By the described analysis of the 261 detailed energy certificates from the Stadtwerke Hannover two “building types” were defined. They reflect an average state of a single-family house and of a multi-family house before modernisation (area and U-values of walls, roofs, windows etc.). Types of heating systems (type and age of the main heat generator depending on the used energy carrier) were accordingly defined.
- The share of building and heat supply system types in the programme was derived from the 254 simplified datasets.
- The number of supported cases for each type of energy saving measures was determined from the programme statistics. By combining this information the energy savings and the carbon dioxide emission reduction could be calculated with the help of a common energy balance method.

The reduction of carbon dioxide emissions achieved by the supported measures in 2005 amounts to circa 5150 tons per year. For 2006 the respective number is circa 5350 tons per year.

During the German model project a DATAMINE interface was implemented in an energy certificate software product. The interface makes possible a direct transfer of the building data and calculation results to a file in the format of the DATAMINE data structure.

Conclusions

The German model project demonstrated the application of the general idea of DATAMINE – monitoring with the help of energy certificate data – to a special situation: the analysis of an energy saving support programme.

The 261 available detailed energy certificates made possible a comprehensive analysis of the state of the buildings sample before modernisation which on the one hand delivered valuable data for the monitoring. On the other hand it can also be seen as a successful “test run” of a more general analysis of the existing building stock with the help of data collection from energy certificates using the DATAMINE data structure.

The monitoring of the proKlima-Altbau programme could be improved in the future. Especially a direct connection of the data of the building in its original state and the individually energy saving measures could lead to an increased accuracy of the calculation of carbon dioxide emission reduction. Four alternative concepts of a future continuous monitoring were elaborated in the project which will be discussed with proKlima. They differ in terms of expenses and accuracy.

A DATAMINE interface was implemented an energy consulting software tool. This approach can simplify data collection in the future.

2 Description of the German Model Project

Objectives and key actors

The climate protection fund proKlima is carried by Stadtwerke Hannover (the regional energy supply company), the city of Hannover and some smaller communities in the Hannover region. The fund supports energy saving measures by some subsidy programmes of which “proKlima-Altbau” – the programme for existing buildings – is the largest one. In 2006 944 applications were allowed and granted with altogether 2.2 million Euro in “proKlima-Altbau”.

The issuing of an energy certificate is a prerequisite for taking part in the programme. The making of the energy certificate is also supported, but since 2006 only, if at least one energy saving measure is carried out in the framework of proKlima-Altbau. So there are good general conditions for the evaluation of the programme with the help of energy certificate data.

Against that background there were the following objectives of the German DATAMINE Model Project:

- Calculation of the carbon dioxide emission reduction which is achieved by the supported energy saving measures in the framework of the proKlima-Altbau programme
- Giving a detailed overview of the state of the thermal envelope and the heat supply system of the funded buildings.
- Elaboration of concepts for a continuous monitoring of proKlima Altbau with the help of energy certificate data

Data collection method

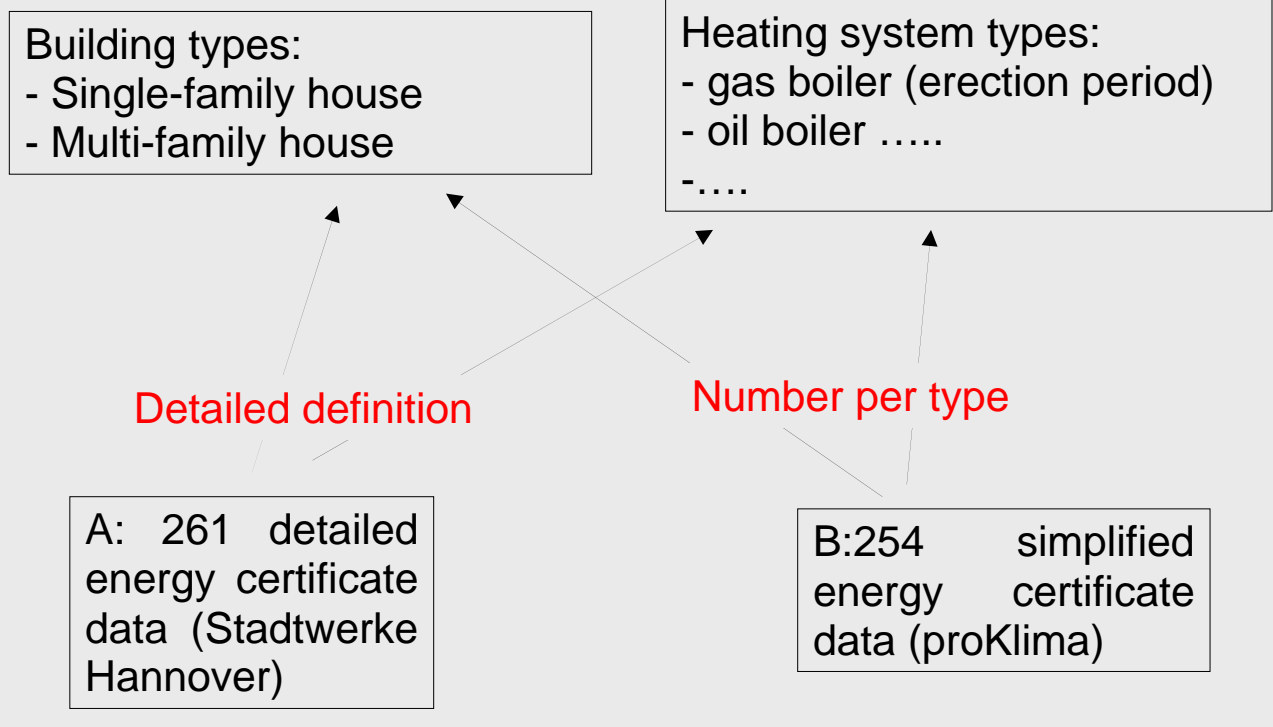
The necessary data were provided by Stadtwerke Hannover and proKlima:

- Detailed data from 261 energy certificates were made available by Stadtwerke Hannover, who also act as energy consultants. This data was the basis for the analysis of the carbon dioxide emission reduction (by definition of building and heat system types) as well as the elaboration of a comprehensive overview of the funded building stock before modernisation. But because all these data were only from this special energy consultant “Stadtwerke” it was not sure, if they would reflect the complete support programme in a representative way – especially with regard to the frequency of building types and energy carriers. For example it might be that energy certificates are more frequently ordered by those customers who also purchase end energy (e. g. gas) for their heating system from the “Stadtwerke” than by those building owners who e.g. use oil for heating.
- Because of that an additional data source was used: There were simplified data sets from 3139 energy certificates available. Those datasets, which include only little information about the energetic state of the buildings¹, are collected by proKlima for every supported building. Among those only 254 data sets could be analysed in this project. These certificates were funded after 1st February 2006 so it was quite sure that the building owners were also funded for concrete energy saving measures and not only for the making of the certificate (as were most of them before 2006 with a backlog of old cases in January 2006).
- Apart from the energy certificate data, which described the state of the buildings before modernisation, the general statistics of the proKlima-Altbau programme were analysed to gain the necessary information of which measures were funded by the house owners. There was detailed information of the number of energy measures per type available, among others the number of buildings with insulation of wall, roof / upper floor ceiling, cellar ceiling / basement,

¹ Usually the living space, the national reference area „Gebäudenutzfläche A_N “, the type of building (single or multi-family house), energy demand per energy carrier, the useful energy demand for space heating, the coefficient of heat transmission losses, the carbon dioxide emissions and the primary energy demand.

new windows and the number of new heat generators per type (gas condensing boiler, heat pump, CHP, connection to district heating, wood boiler).
The following pictures shows in which way the 261 detailed and the 254 simplified datasets were combined to attain the necessary information about the supported buildings.

Fig. 6: Combination of energy certificate data sources



3 Data Evaluation

Reduction of carbon dioxide emissions

The following figures Fig. 7 and Fig. 8 show the data of the building and heat supply system types which were determined by the analysis of the 261 detailed Stadtwerke Hannover datasets.

**Fig. 7: Data of the two building types
(roof: also upper floor ceiling, basement: also cellar ceiling)**

single-family house				
	wall	roof	basement	windows
element area / living space (m ² /m ²)	0,98	0,80	0,66	0,22
fraction: insulated	32%	53%	6%	22%
U-value (W/m ² K)	0,39	0,34	0,32	1,67
fraction: not insulated	68%	47%	94%	78%
U-value (W/m ² K)	1,22	1,08	0,98	2,97
multi-family house				
	wall	roof	basement	windows
element area / living space (m ² /m ²)	0,62	0,38	0,33	0,19
fraction: insulated	18%	42%	1%	4%
U-value (W/m ² K)	0,37	0,34	0,44	1,60
fraction: not insulated	82%	58%	99%	96%
U-value (W/m ² K)	1,44	1,17	1,07	2,92

Fig. 8: Data of the heating system types (gas and oil) depending on the erection year of the boiler

energy carrier	single-family house		multi-family house		
	gas	oil	gas (central)	gas (dwelling)	oil
constant temperature boiler					
until 1986	17,8%	21,4%	0,9%	8,1%	14,3%
1987-1994	15,1%	7,1%	1,8%	33,3%	7,1%
since 1995	8,2%	0,0%	4,5%	20,7%	7,1%
low temperature boiler	0	0	0	0	0
until 1986	4,1%	7,1%	0,9%	0,9%	7,1%
1987-1994	17,8%	28,6%	7,2%	0,9%	14,3%
since 1995	8,2%	35,7%	8,1%	1,8%	50,0%
condensing boiler	0	0	0	0	0
until 1986	0,0%	0,0%	0,0%	0,0%	0,0%
1987-1994	5,5%	0,0%	2,7%	0,0%	0,0%
since 1995	23,3%	0,0%	8,1%	0,0%	0,0%
sum	100,0%	100,0%	gas total:	100,0%	100,0%
number of cases (= 100 %)	73	14	gas total:	111	14

The frequency of building types and heating system types was calculated by analysing the 254 simplified proKlima datasets. The fraction of building types is 49 % (single family houses) and 51 % (multi-family houses). The mean living space per building is 163 m² or 620 m², respectively. The fraction of energy carriers is shown in the next figure.

Fig. 9: frequency of energy carriers used for heating

	single family house	multi family house
gas	87,2%	76,9%
oil	7,2%	13,8%
district heating	0,8%	6,2%
electricity	4,8%	3,1%
<i>sum</i>	<i>100,0%</i>	<i>100,0%</i>
number (= 100 %)	125	129

This data altogether allowed the calculation of the heating energy demand and the carbon dioxide emissions of the two building types before modernisation. The results were as follows (all values related to the living space):

- useful energy demand for space heating:
single-family house: 205 kWh/m²a
multi-family house: 142 kWh/m²a
- carbon dioxide emissions for space heating and hot water (equivalent emissions including exploration and transport of energy carriers):
single-family house: 82 kg/m²a
multi-family house: 56 kg/m²a

The total carbon dioxide emissions of the buildings granted in 2005 and 2006 as well as the attained energy and carbon dioxide savings were calculated with the help of the statistics of the proKlima-Altbau programme. Because it was not possible to assign concrete measures to single buildings (so it was for example not clear to which extent packages of measures were funded) but only the total number of the respective energy saving measures was available for each year, some simplifying assumptions had to be made².

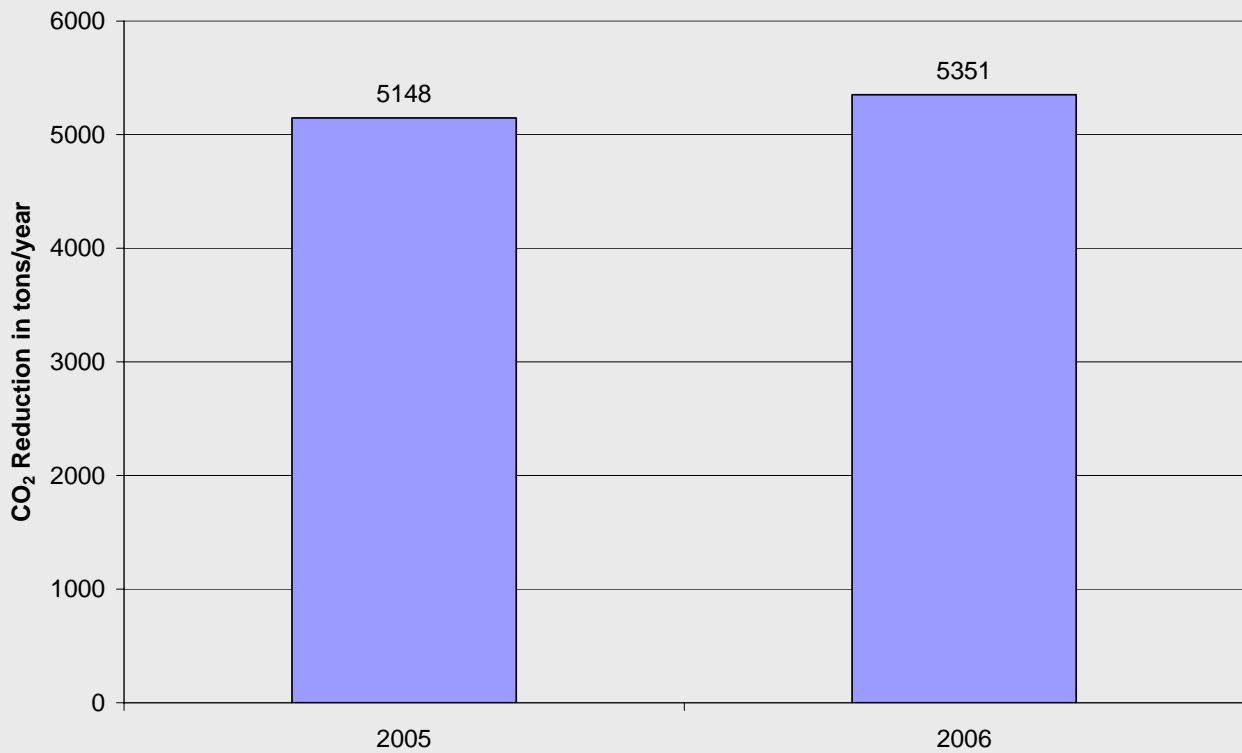
So the heating energy demand and the carbon dioxide emission after modernisation could be estimated. The mean values for the years 2005 and 2006 are given here:

- Useful energy demand for space heating:
single-family house: 153 kWh/m²a
multi-family house: 110 kWh/m²a
- carbon dioxide emissions for space heating and hot water (equivalent emissions including exploration and transport of energy carriers):
single-family house: 58 kg/m²a
multi-family house: 44 kg/m²a

Fig. 10 shows the annual carbon dioxide emission reduction attained by all supported measures of the programme proKlima-Altbau in 2005 and 2006.

² More details are provided in the extended report in German.

Fig. 10: Saving of carbon dioxide emissions by the measures which were funded in the proKlima-Altbau programme in 2005 and 2006



The project also aimed at the elaboration of concepts for a continuous monitoring of the proKlima-Altbau programme in the following years. Four different solution approaches were introduced. They differ in terms of the necessary effort and the accuracy of the calculated carbon dioxide savings. In all four concepts an improved exactness is achieved by a direct combination of the information of the building in its original state on the one hand and the individually chosen energy saving measures on the other hand.

1. Collection of detailed energy certificate data about the state before and after modernisation:
This could be realised by implementing a DATAMINE interface in all used energy certificate software tools³ and by the carrying out of energy balance calculations of the building state before and after modernisation. This concept would make the most effort but it is not unrealistic because the making of an energy certificate is usually combined with energy consultancy, that means the state before and after modernisation is calculated anyway.
2. Collection of detailed energy certificate data about the building state before modernisation and combination with the data of the granted energy saving measures:
This concept is simpler than the first one because only one energy balance calculation per building is necessary. But also here a DATAMINE interface for all software tools would be necessary or the data collection again would have to be restricted to a sample.
3. Monitoring according to the method in the DATAMINE model project:
Also in the future the data collection and evaluation could be done in the way like it was in the DATAMINE model project. The building and heat system types which were defined in the model project could be used, but this “typology” should be updated after some years. As a major improvement of the method a direct connection of the data of the buildings (simplified energy certificate data) and the granted measures should be made possible so that e.g. packages of measures and changes of energy carriers could be considered which would lead to a better accuracy of the results.

³ If not all used software tools are equipped the analysis will have to be restricted to a sample of datasets.

4. Data collection by a questionnaire:

The DATA collection needs not necessarily to be carried out with the help of the energy certificates. It is also possible to let the supported house owners fill in questionnaires (about two or three pages) and to collect the data according to the DATAMINE scheme. This will be a possible option if for example the programme conditions change and there is no longer a direct connection between issuing an energy certificate and getting a grant in the future. But also now this could be a practical alternative for data collection.

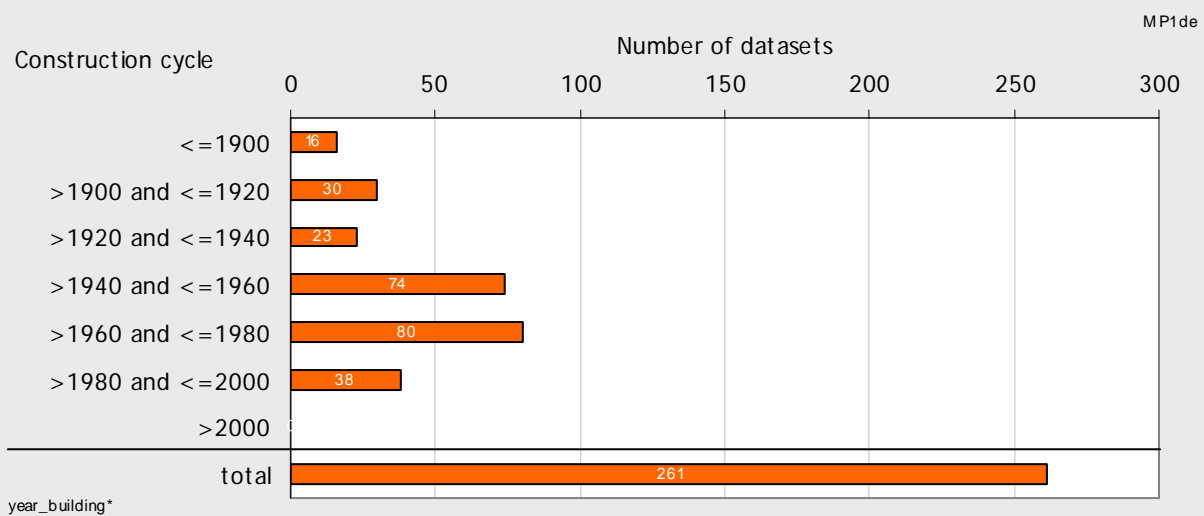
General statistics

In this chapter a more detailed overview of the state of the granted buildings before the modernisation is given. The following figures were made by analysing the 261 energy certificates of Stadtwerke Hannover. The data transfer from the files of the energy certificate software to the DATAMINE data base were carried out by an interface which was implemented in the energy certificate software.

Here only an excerpt of the comprehensive analysis in the German report is given. It aims here at demonstrating the chances of getting basic information about the building stock by evaluation of energy certificate data. Detailed information about the energetic state of the building envelope, the heat supply system for space heating and hot water and the results of the energy balance calculations (for the individual energy certificates) are provided.

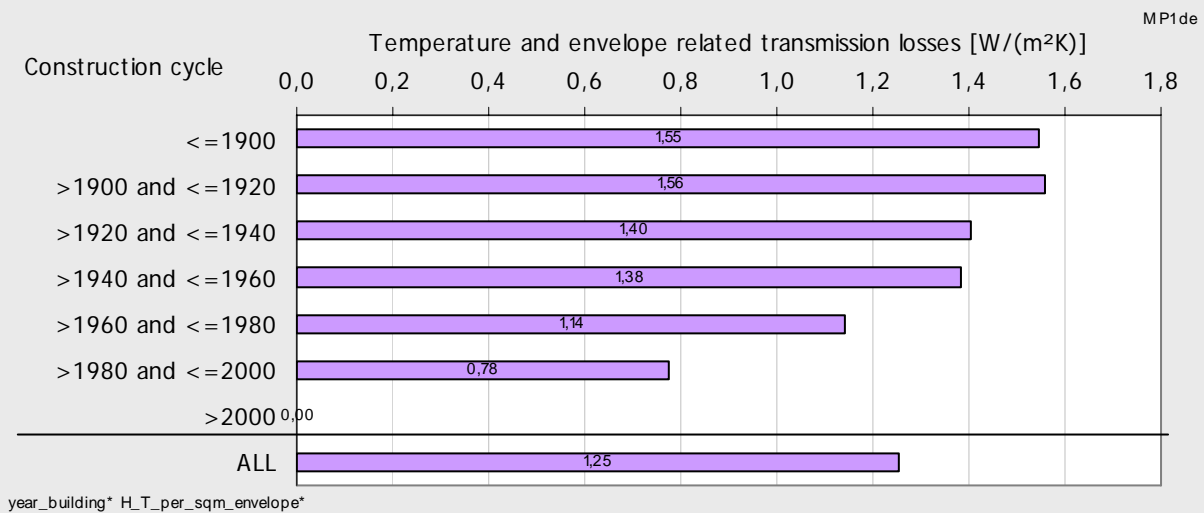
The first figure shows the construction period of the examined buildings. Most of the buildings were erected after 1945.

Fig. 11: Frequency of building construction cycle



The transmission losses defined by a German standard shown in Fig. 12 are comparable to (but not identical with) the mean U-value of the complete building envelope (consisting of walls, roof / upper floor ceilings, windows and basements / cellar ceilings). Generally speaking the values are very high until 1960, not very much differing on building age in this period. First improvements can be observed in the years 1960 to 1980 (with the first oil crisis belonging to this era), a major decrease of the heat losses could be achieved after 1980.

Fig. 12: Transmission losses per m² envelope (similar to mean U-Value of the envelope), dependence on building construction cycle



The following diagrams provide information about the average U-values of the elements of the building envelope depending on the construction period of the building. So they show in more detail how the different building elements contribute to the heat losses. For example it can be seen that in contrast with the other elements the U-values of windows (see Fig. 14) do not very much depend on the age of the building. This is probably because the lifetime of windows is much shorter than of other measures so that the old single-glass windows have been already exchanged in most of the buildings.

Fig. 13: Mean U-Value of walls, dependence on building construction cycle

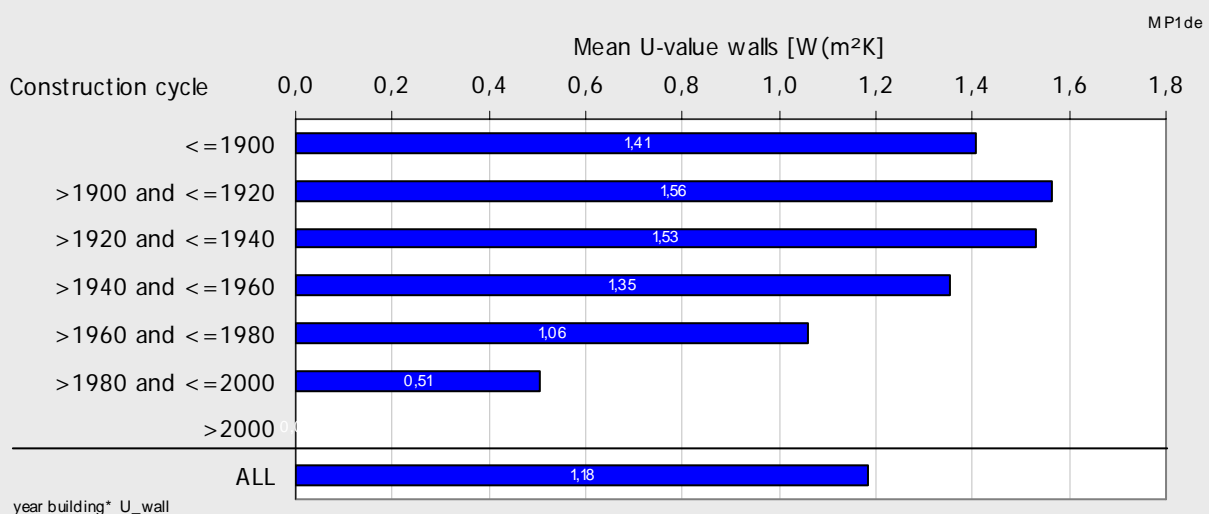


Fig. 14: Mean U-Value of windows, dependence on building construction cycle

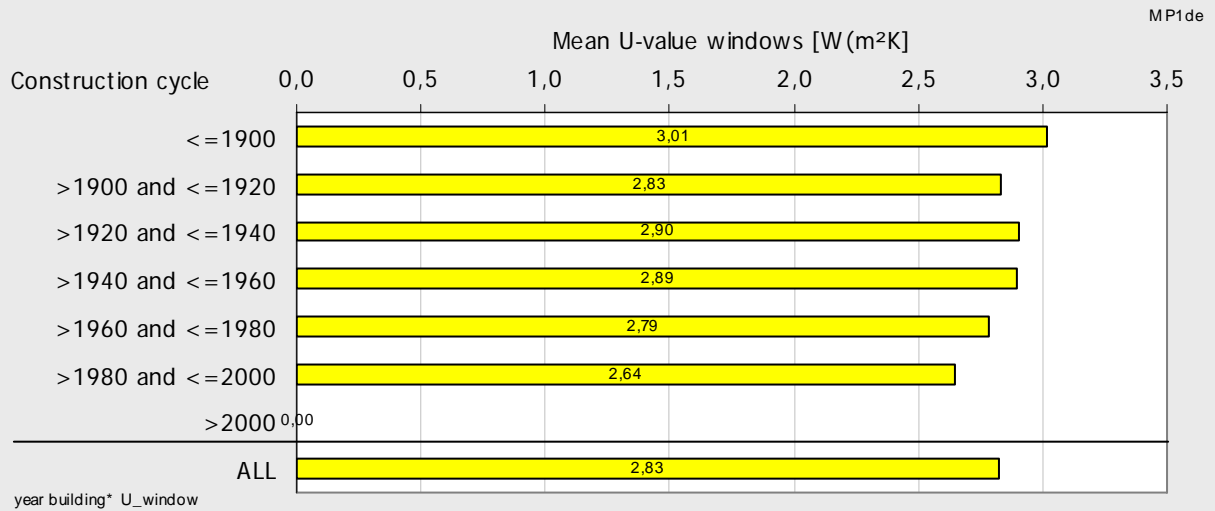


Fig. 15: Mean U-Value of roofs or top ceilings, dependence on building construction cycle

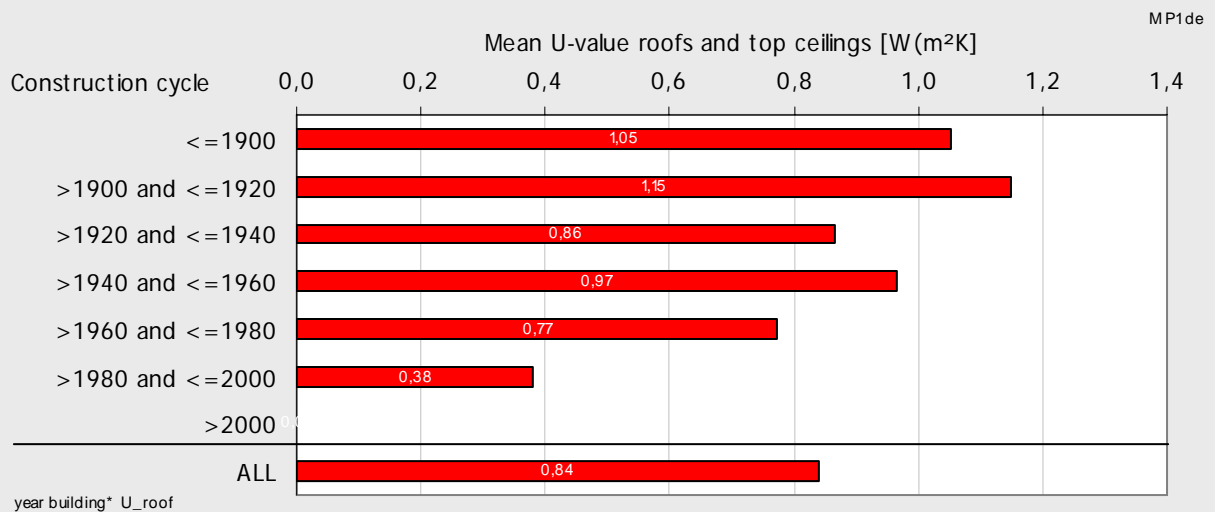
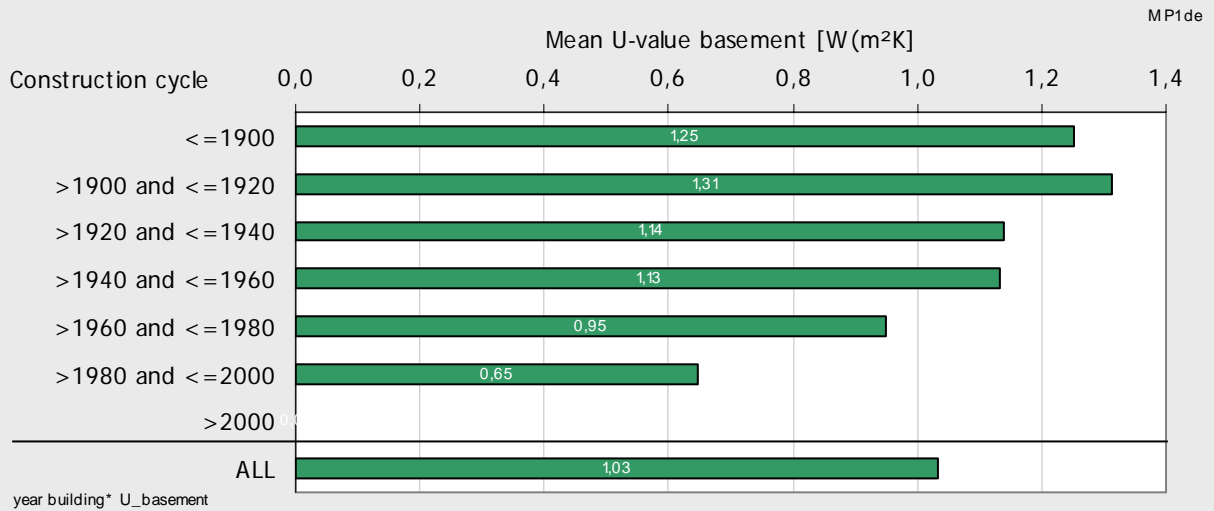


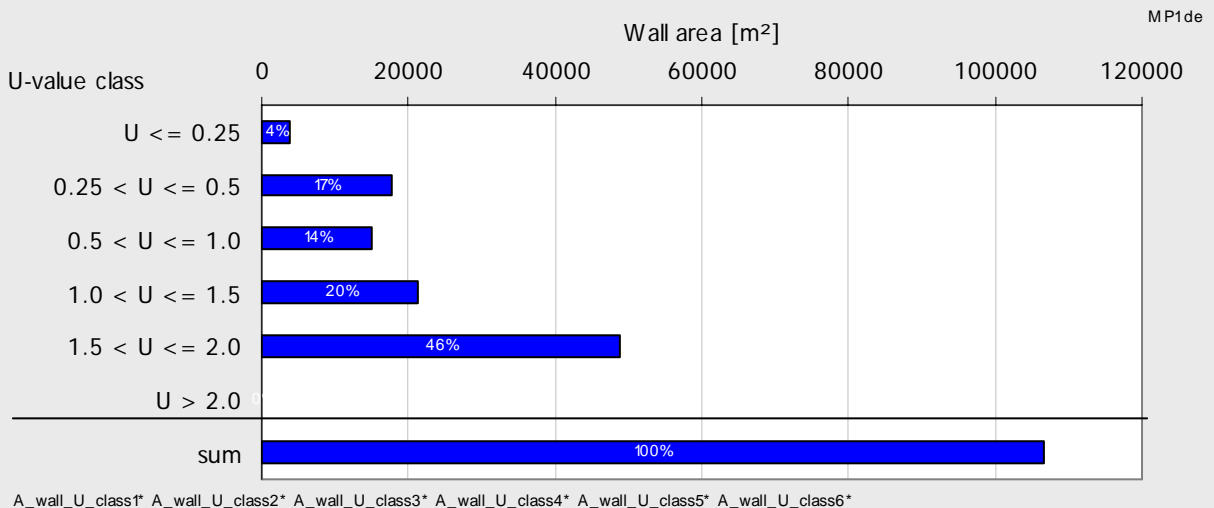
Fig. 16: Mean U-Value of basement (floor of bottom conditioned storey over cellar or soil), dependence on building construction cycle



Here as an example the distribution of wall area is shown for different classes of U-values. With this type of chart one can examine the frequency of different energy qualities of walls (whereas in case of mean U-values as above one can not be sure if e.g. the wall quality is “medium” or if it is a mix of very high and very low quality).

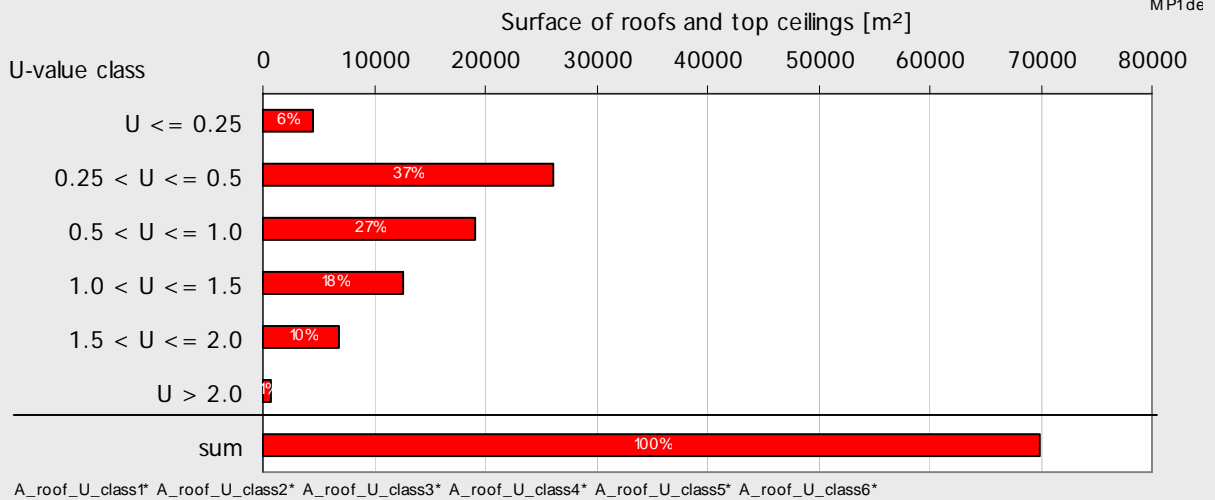
One can see that 17 % of the walls have U-values between 0.25 and 0.5 W/m²K and thus have probably been provided with a considerable layer of insulation material. Another 4 % are very good insulated ($U < 0.25$ W/m²K).

Fig. 17: Total wall surface for different classes of U-values



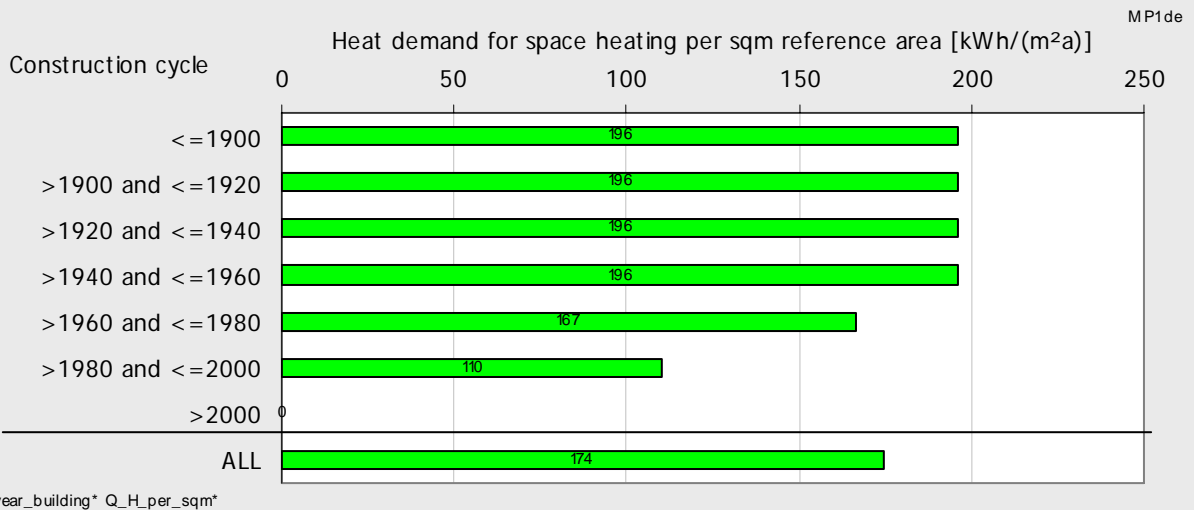
In comparison the frequency of good insulated roofs or upper floor ceilings is considerably higher, as Fig. 18 shows: 43 % of those elements have an U-value of less than 0.5 W/m²K

Fig. 18: Total surface of roofs and top ceilings for different classes of U-values



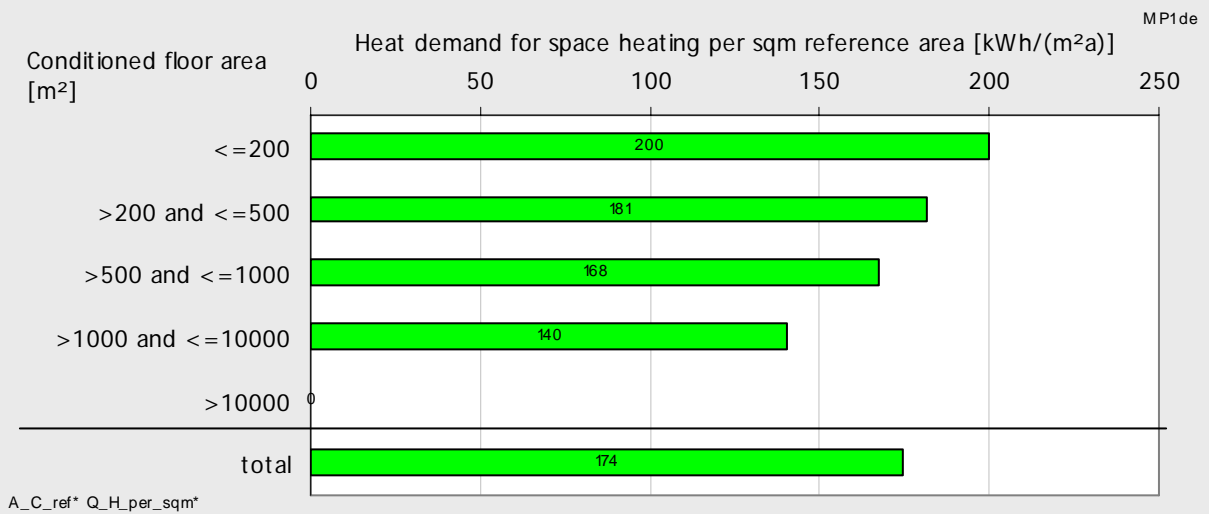
In the following pictures the energy demand for space heating (calculated during the making of the energy certificate) is analysed depending on the construction period and the size of the building (measured by the conditioned floor area), respectively. The dependence on the construction period in Fig. 19 is in line with the results for thermal building insulation in Fig. 12. There is a decrease of heat demand for buildings which were erected after 1980. (It was checked that it is indeed a pure chance that the first four values in the figure are identical.)

Fig. 19: Mean values for the calculated useful energy demand for space heating – dependence on building construction cycle



As expected the energy demand for space heating decreases with the size of the building, as Fig. 20 shows.

Fig. 20: Mean values for the calculated useful energy demand for space heating – dependence on building size

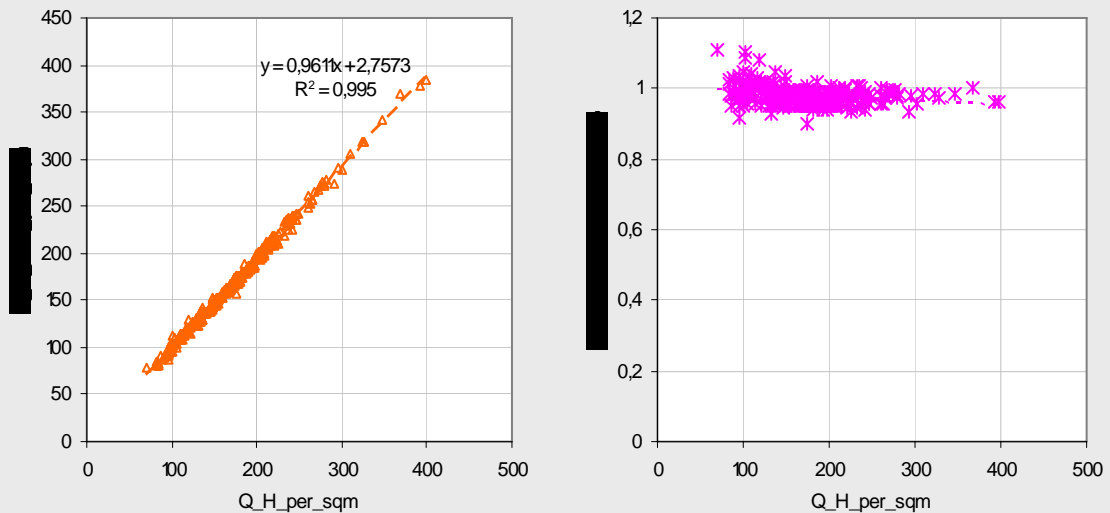


A plausibility check for the space heating energy demand was carried out by comparing the values given in the energy certificate (that means calculated by the original energy certificate software tool) with the results of a simplified calculation⁴ on basis of the above given transmission losses per m² envelope area (see Fig. 12), the window areas and g-values and annual German climate data. The figure shows that there is a very good correspondence of both values. This analysis can be interpreted as a simple plausibility check for energy certificates (concerning space heating).

Fig. 21: Plausibility check for the energy demand for space heating

x-axis: original value from the energy certificate

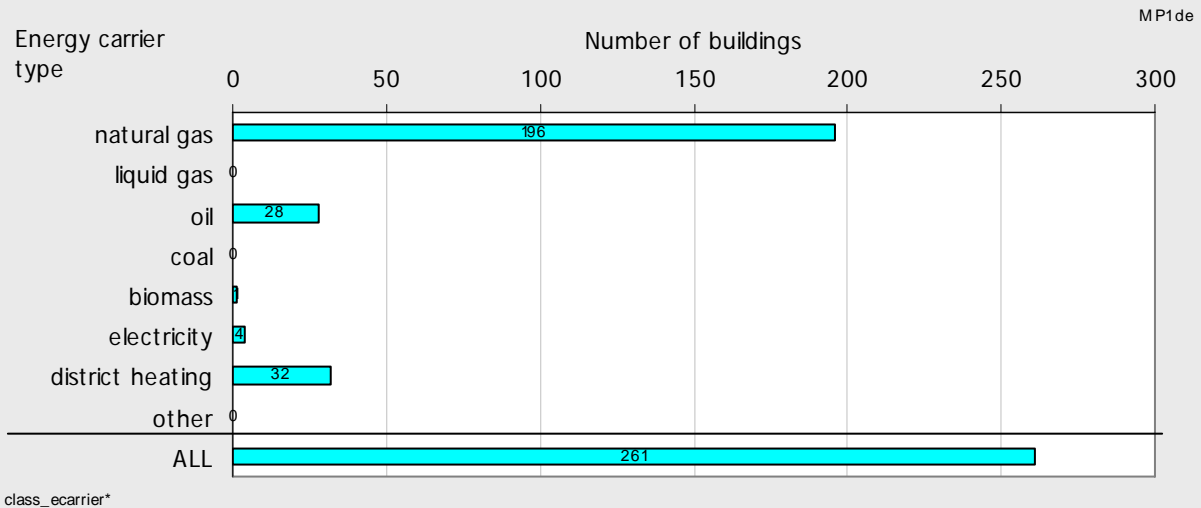
y-Achse: value calculated by the simplified method⁴ (left) / relation to the original value (right)



The next figures provide information about the heat supply systems. The most common energy carrier used for heat generation in the Hannover region is natural gas (circa 75 %). The share of oil (which is more common in German rural areas) and district heating is only a bit above 10 %.

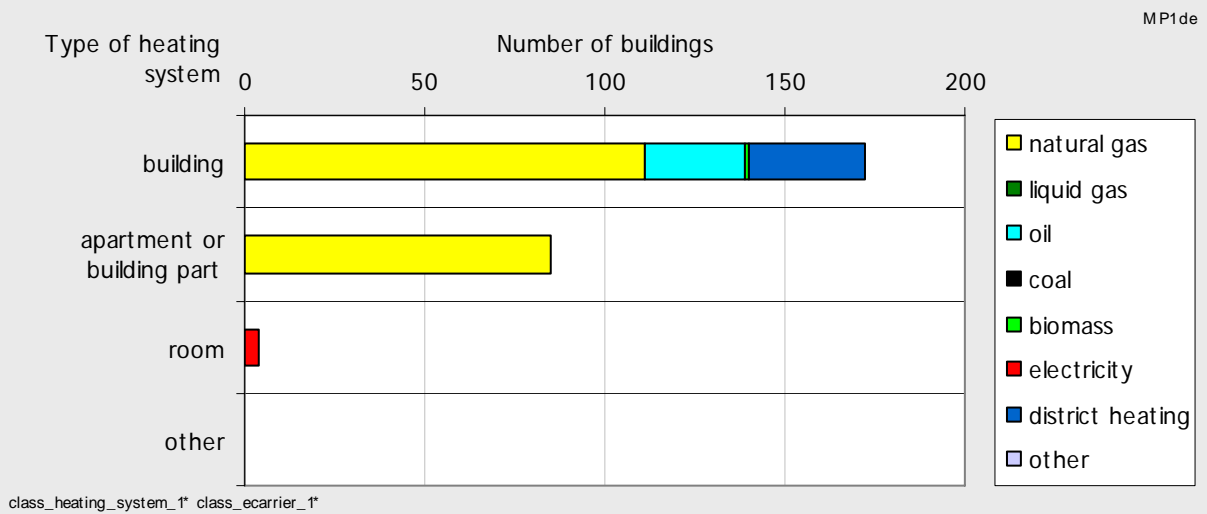
⁴ Formula of the applied simplified seasonal method: $(H_{\text{Transmission}} + 0.19 \cdot V_{\text{C}}) \cdot 75 - 0.9 \cdot (0.567 \cdot g_{\text{window}} \cdot (A_{\text{window_south}} \cdot 410 + A_{\text{window_west}} \cdot 300 + A_{\text{window_east}} \cdot 300 + A_{\text{window_north}} \cdot 185) + 22 \cdot 0.32 \cdot V_{\text{C}})$

Fig. 22: Frequency of energy carriers used by the main heat generator



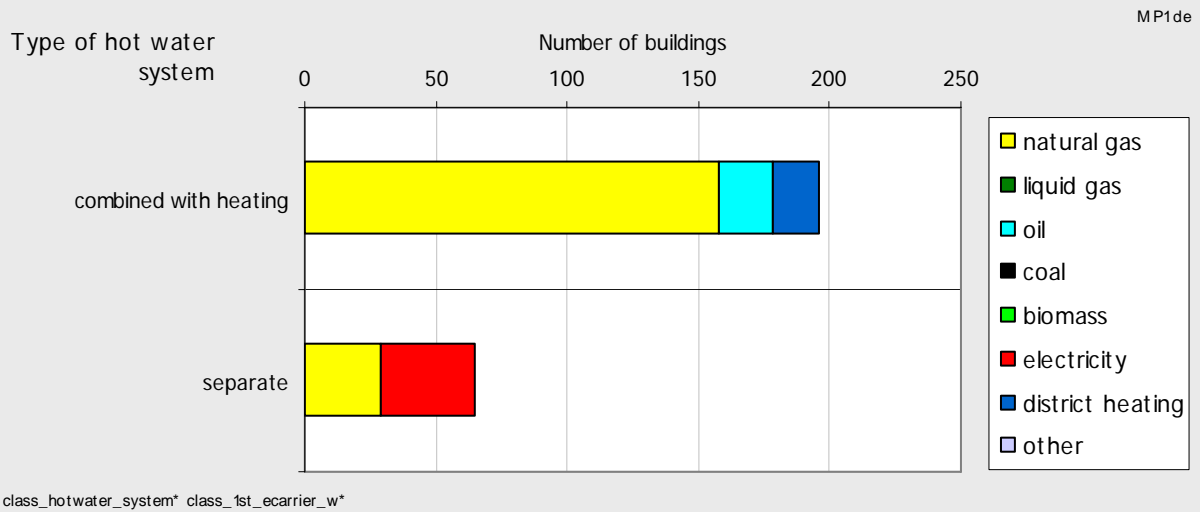
In the most cases there is a central heat supply system for the whole building, but in multi-family houses the supply of the single apartments by small gas heaters is also quite common.

Fig. 23: Frequency of space heating system types (centralisation grade) + main energy carrier



The hot water system is usually combined with the heating system, but in about 25 % of the buildings there are separate heat generators for the hot water production which use gas or electricity.

Fig. 24: Frequency of hot water system types + respective energy carriers (main hot water system)



The following figures show that before modernisation mostly low-temperature or even constant temperature boilers were used.

Fig. 25: Frequency of heat generator types for combustion of fuels + respective energy carriers

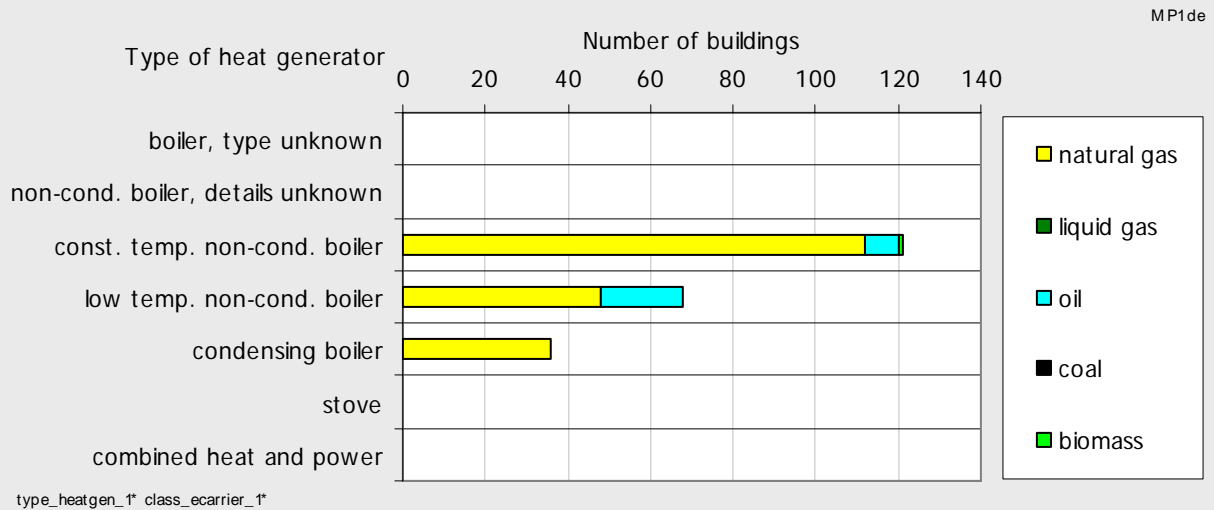
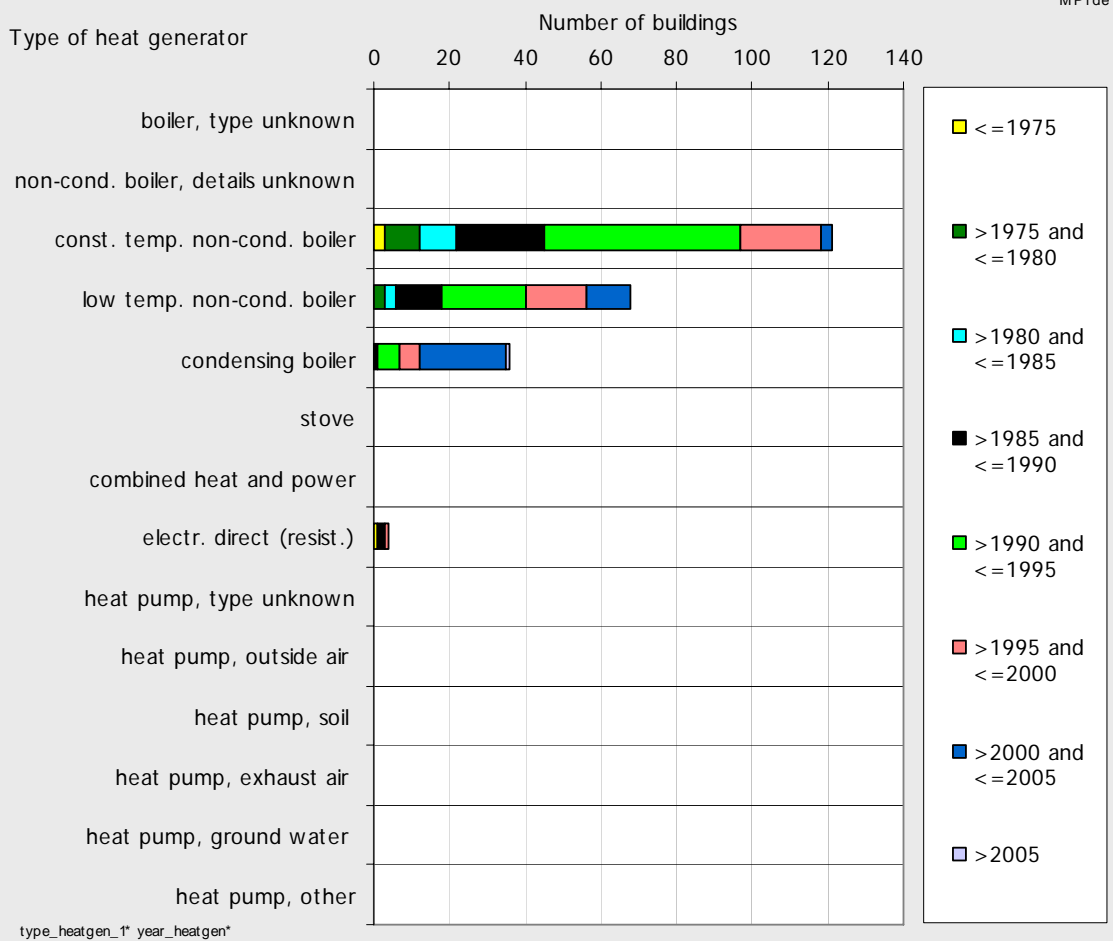
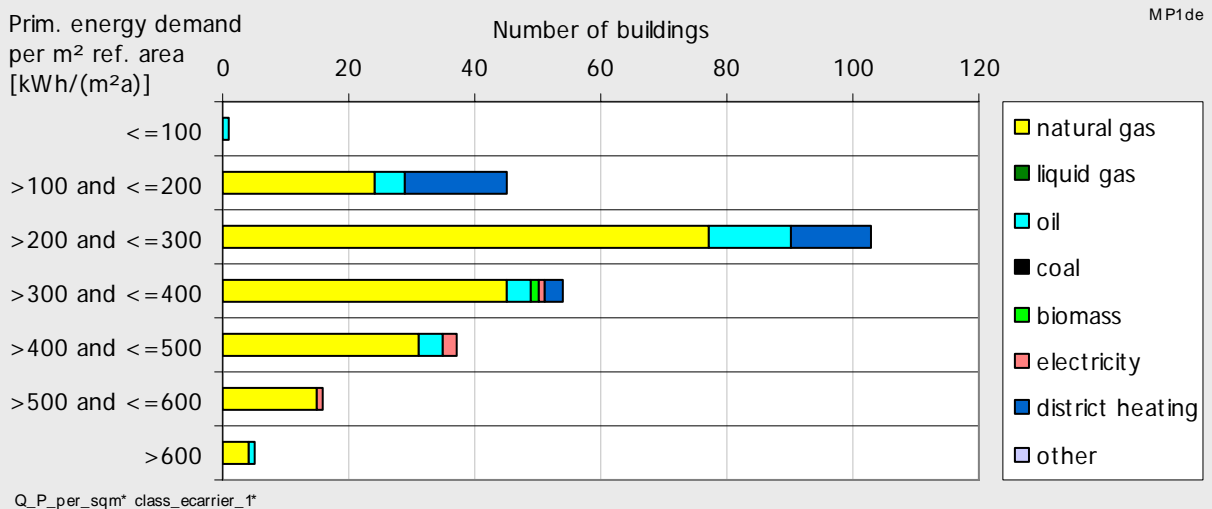


Fig. 26: Frequency of heat generator construction cycles (fuels and electricity)



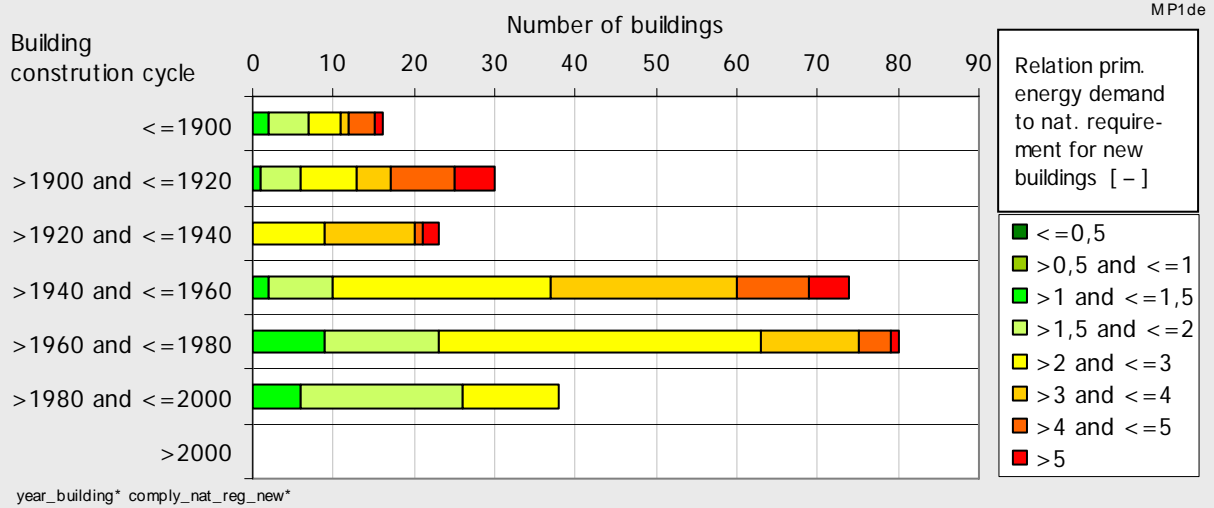
The last two figures of this chapter show results for the calculated primary energy demand (frequency distribution depending on energy carrier and in comparison with the requirements for new buildings, respectively). The most of the values of the primary energy demand are in a range of 200 to 400 kWh/m²a.

Fig. 27: Frequency of primary energy demand (energy carriers used by the main heat generator)



In case of district heating there is a tendency of lower values which can be explained by the low primary energy factors of district heating due to the utilisation of cogeneration plants.
 Fig. 28 shows that as expected the primary energy demand of most of the buildings is considerably (normally more than a factor 2) above the value demanded for a today's new building of the same size and shape.

Fig. 28: Frequency of compliance with national requirements for new buildings
 – calculated primary energy demand in relation to the requirements of the German building regulations for new buildings / partition into building construction cycles



4 Conclusions

The German model project showed that the monitoring of an energy saving grant programme according to the DATAMINE approach – that means with the help of a systematic data collection from energy certificates – is possible. The carbon dioxide emission reduction which was attained by the measures in the years 2005 and 2006 could be calculated. Apart from that a detailed survey of the stock of supported buildings before modernisation could be given concerning the state of the building envelope elements, the heat supply system and the energy demand. In the view of a possible continuous monitoring of the programme proKlima-Altbau in the future four alternatively applicable concepts were elaborated.

The datasets of 515 energy certificates were analysed:

- The datasets of the 261 energy certificates from Stadtwerke Hannover included very detailed information. 189 of the 255 data fields of the DATAMINE data structure could be filled in (see Fig. 29).
- The 254 simplified energy certificate data from proKlima included only little information about the energy performance of the buildings which was nevertheless important for the analysis of the achieved carbon dioxide savings. Circa 30 DATAMINE data fields could be filled in.

Further 2885 datasets were transferred to the DATAMINE data structure in the same way, even if they could not be used in the analysis of the achieved carbon dioxide savings. So altogether the data of 3400 energy certificates were collected in the DATAMINE format.

A DATAMINE interface was implemented in an energy certificate software tool. It makes possible to create an output in the format of the harmonised data structure at the time when the energy certificate is issued. This can simplify the collection of energy certificate data in the future.

Fig. 29: Frequency of used data fields (261 energy certificates from Stadtwerke Hannover)

