Green Solar Cities

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The Green Quality Building Process concepts

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Introduction

This report has been prepared to inspire to obtain a high quality of the Green Solar Cities demonstration projects and hereby support the demands of the EU-Energy Performance Directive for Buildings (EPDB). Both experiences from new build housing projects and retrofit housing projects are presented here, mainly based on Danish experiences.

The report first gives an introduction to the Green Quality Building Process and performance verification procedures. After this promotion ideas concerning energy (+) and energy quality building and renovation is presented, and there is also a chapter with new R&D results on heat recovery ventilations systems. Finally there is a presentation of practical use of intelligent Energy(+) and Energy Quality Implementation R&D work in connection to the development of a CO2 neutral rooftop apartment and the Danish concrete housing block retrofit demonstration project.

In the report there is a short introduction to different verification methodologies like blower door test, thermography and energy signatures.
A blower door test is made to measure the air tightness of a building and to find air leakages. The measurement can be improved further by help of an infrared camera, which can find cold bridges in the building by taking thermograph pictures.
An energy characteristic/ energy signature can be made by monitoring energy consumption and by using a computer programme made in an excel sheet where a graph can be drawn that shows the energy consumption in W/m^2 vs. the ambient temperature. Both as monitored and calculated.

In 2002 Cenergia launched the Green Quality Building Process as a way to ensure that building projects also in reality could live up to the demands of the EU-Energy Performance Directive for Buildings (EPDB) which in e.g. Denmark means that a 25-30% saving on energy use has been introduced by 1st January 2006 while 25% more should be saved 5 years later, by 2011, and another 25% saving should be introduced 5 years later again in 2016. This is also always based on an energy frame value which includes both heating, DHW and electricity use for operation.

To promote the use of the coming minimum demands for 2011 and 2016 these low energy qualities was already introduced in Denmark by January 2006 as protected low energy classes 2 and 1 respectively, and can be used both for new build and retrofit building projects.

But when it comes to retrofit projects it is possible in Denmark only to focus on use of cost effective demands for U-values like in the old building regulations for new build, but since it except in one family housing will be necessary to utilise heat recovery ventilation, then it should be possible to show to builders that it is a benefit for the builder to utilise an energy frame based energy quality also for retrofit so you have a good chance obtain high savings on operation costs.

The introduction of energy quality demands concerning retrofit projects are new in both Austria and Denmark. But it is clear that it would be of great value if similar key frame values for energy use, as for new build, is introduced as a general solution also for retrofit. Here it can e.g. be possible to work with a classification system with different qualities like A, B and C, and there could also with respect to energy be referred to the energy frame values mentioned in the sustainability evaluation protocol.

If overall energy frame values consisting of both heat and electricity for operation values are added together (based on a factor 2.5 for the relation between heat and electricity), then it is possible to identify energy (+) and energy (++) building as a quality which is one or two steps beyond the minimum energy demands both for new build and retrofit.

At the same time it is very important to be able to control the energy quality for realised building projects both for new build and retrofit. Here a performance verification procedure (PVP) should be introduced with the following minimum requirements:

1. Monitoring of air tightness and cold bridges with blower door tests and thermo photography equipment. This should be based on clear demands for the quality, e.g. maximum 0.1 air change per hour as natural ventilation and limitation of “line losses” to a certain value defined by the start of the building project. Practically this should be made with an air tightness control already when e.g. a housing unit is finalised or renovated as a quality control, and later as a general quality control.

2. Use of an energy characteristic / energy signature procedure to document the overall energy use for heating and DHW measured in W/m² as a function of the outdoor temperature.
   This can be made during 3 - 4 months during the first year of operation. Here monitored data can be used to produce a regression line which can be coupled to an already calculated energy signature as a quality control. See also the enclosed “Programme for Evaluation of Energy Performance in Buildings” (see annex)

3. Monitoring of common electricity use divided up in e.g. ventilation fans, lighting, pumps and lifts.

The Green Quality Building Process has been applied to the involved pilot renovation projects in another EU project called “Demohouse”. The result has been a much more clear focus on energy quality than in normal housing retrofit projects involving airtightness control, thermo photography and use of energy signatures as a quick and very illustrative follow-up on operation conditions and obtained energy savings.

1 The Green Quality Building Process

In figure 1.1 the idea of the overall Green Quality Building Process is illustrated, which also includes the use of Green Quality Points, which can be calculated by help of the Green Build Questionnaire or the Green Diploma System.
(See also the annexes on this where there e.g. are a translated version of the Green Build Questionnaire specially developed for retrofit housing projects, as well as a translated revision of the Green Diploma System).

The Green Quality Building Process is consisting of the following:

1. Green Quality Classification with classes A, B, C, D, E …. →	Based on performance demands e.g. for best available technologies. Here f.ex an Energy(+) or Energy(++) standard can be documented aiming at qualities one or two steps beyond the minimum demands.
↓ 2. Green Quality Points (e.g. based on Green Build system)	
3. Green Quality Evaluation →	Check system concerning performance demands. Use of performance verifications procedure (PVP). Use of green quality model. Development of certification system.
4. Green Quality Financiation (e.g. with special low interest rate options)	

Based on

a) <u>total economy</u> analysis /optimisation } b) life-cycle quality of chosen solutions	Economic energy saving packages can be realised Quality and Performance Optimisation.
c) use of general sustainability } d) green quality points can be used to obtain support for necessary process concerning quality measures like energy quality control.	Necessary allocation of f.ex 1/2 % of total investment for item d and perhaps also item c).
5. Training Activities.	E.g. use of Green Catalogue system and best practice examples.
6. Awareness Campaigns and general promotions:	-Involving the users -Can be promoted more easily when it is

	possible to document good results and a transparent and reliable financing system.
7. Demonstration Activities:	Here can e.g. be shown an optimised balance between energy savings and a necessary high quality indoor air climate and adapted low cost energy supply solutions for low energy building.
8. Implementation campaigns:	Here a co-operation with recognised independent organisations can be useful like, WWF e.g. also in connection to certification.

By help of the Green Quality Building Process it is the idea to develop a certified system for promotion of energy savings and sustainability in buildings. This can e.g. be done by help of the methods mentioned in chapter 3 of this report.

In the following is shown how the Green Quality Building Process is defined from using Green Quality Points (1), use of the Green Catalogue with performance requirements for best available technologies (2), Green Accounting for follow up (3), and Green Diploma as a quality

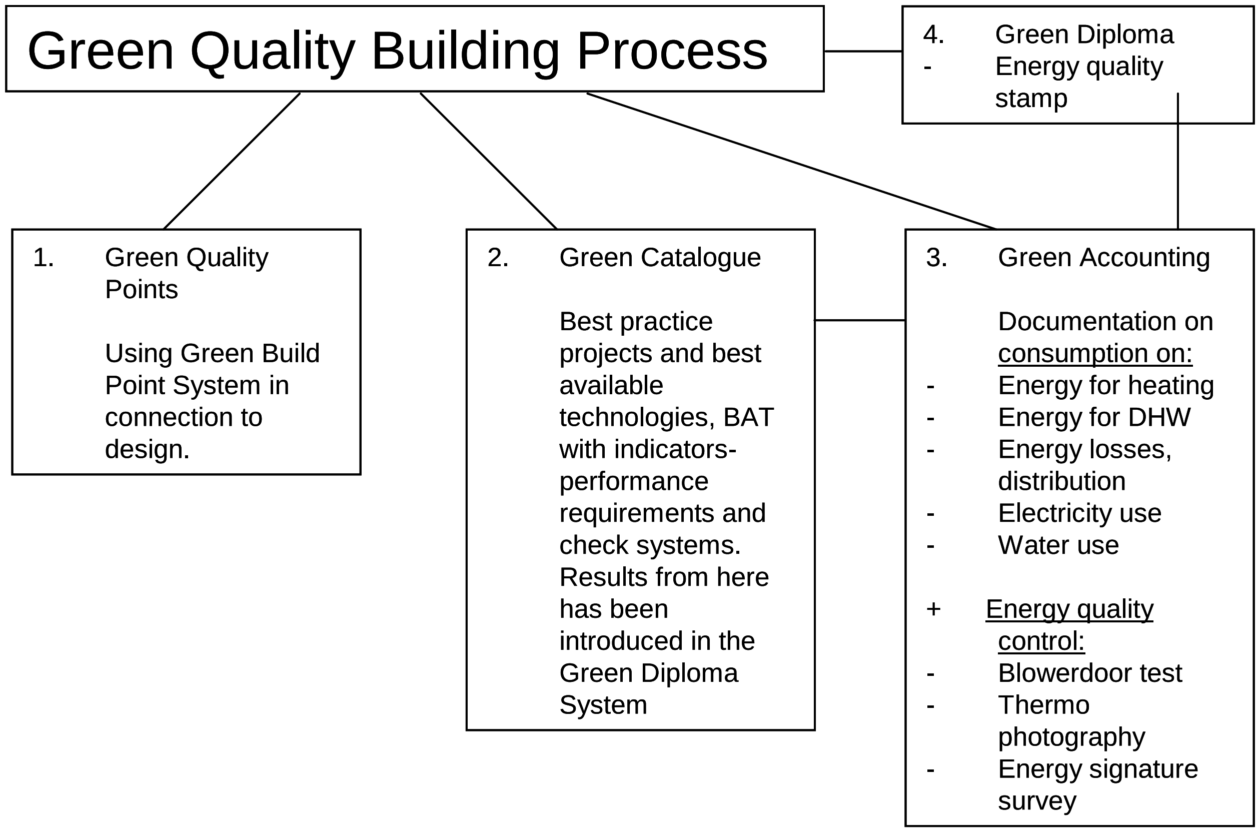


Fig. 1.1.

Above is an illustration of the Green Quality Building Process. This can also be explained in the following way.

First you check the general quality of your aimed at sustainable and energy efficient renovation project by filling in your Green Build Point System (1), to see if your approach is acceptable. Then you can use the Green Diploma System (4) as an energy (and environmental) quality stamp you aim to reach.

Here you can aim at a low energy design in one out of 3 improved levels, which you compare to the national minimum quality of housing renovations projects. The 3 levels are suggested as:
National demands in connection to a "New build level" or a slightly improvement of this (which is the minimum standard to obtain the Green Diploma), Low Energy Class 2 level (which is 25% better than the national minimum demands for new build and which secures a Low Energy Green Diploma) or the Energy Plus level which can either be defined as a Low Energy Class 1 level (which is 50% better than the new build standard) or a Passive House Standard securing an Energy Plus Standard.
In all cases you need to identify indicators, performance requirements and check systems for a number of best available technologies, like insulation, windows, ventilations systems etc. Work on the Green Catalogue in Denmark has been used as the input to create the Green Diploma demands.
And to ensure the energy quality is not just talk, then you use Green Accounting (3) with energy quality control and documentation of key figures to document the energy quality. This can also be connected to the normal energy certification procedures in each country.

In the following chapters a presentation is made concerning:
Verification methodologies in chapter 2, Promotion of low energy building and renovation by help of intelligent Energy(+) and energy quality implementation in chapter 3. And in chapter 4 and 5 practical R&D activities in Denmark are presented.

2 Green Quality Building Process, overview

2.1 Green Quality Classification

As mentioned in chapter 1, tablee 1.1., a Green Quality Classification can be made e.g. using energy (+) or energy (++) classes as already proposed in previous Green Catalogue activities, (see www.greencatalogue.com). Here the energy (+) standard is one step beyond the existing minimum demands and energy (++) is two steps beyond. This can e.g. be linked to the expected improved energy demands in the EU member countries which according to the EU-Energy Performance Directive for Buildings should come into force at least every 5 years. So e.g. in 2011 and 2016.

2.2 New energy demands for new building and retrofit in Denmark

The proposed "Energy (+)" standard for a sustainable and energy efficient building quality introduces an energy efficiency standard which goes beyond the new minimum demands concerning energy quality for new build and renovation which anyway needs to be improved again 5 years later (in 2011).

This means that a logic definition of the energy (+) standard concerning energy use could be to use this to be able to introduce the expected minimum energy standard for 2011 already from 2006.
In Denmark this is handled by introducing two new protected low energy standards in the building regulations, low energy class 2 which is 25 % better than the new minimum standard

of 2006 as an indicator of the expected 2011 demands, and low energy class 1 which is 50 % better. This is illustrated in fig 2.1 below.

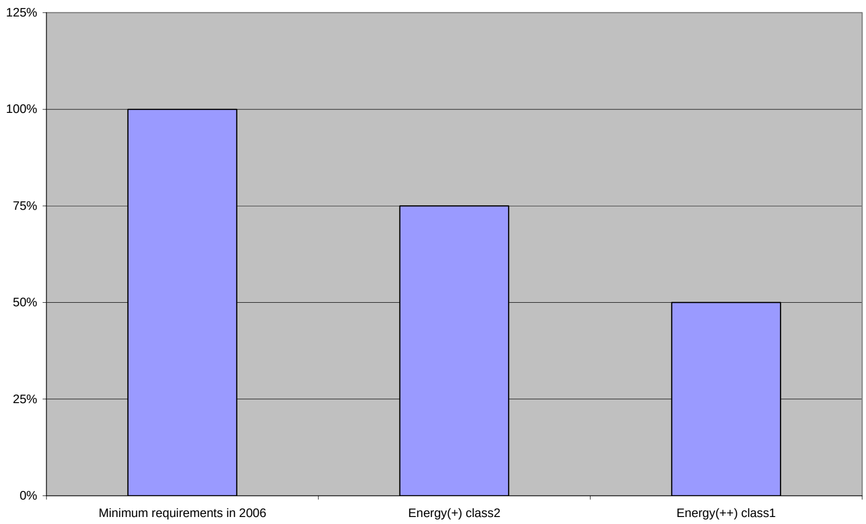


Fig 2.1. Class 2 and 1 buildings compared to the 2006 standard anticipating the requirements for 2011 and 2016.

From 2006 Danish building projects will have to follow the new energy rules in the Danish Building Regulations with a general demand for 25-30% energy savings compared to before and with a demand for energy certification by an independent energy consultant.

For new building and large scale retrofit projects an overall energy frame value will have to be calculated which includes energy use for heating, domestic hot water and electricity use for operation of fans, pumps, lighting and cooling as something new.
The mentioned electricity use for operation is here added to the heat consumption after multiplying with a factor of 2.5 to account for higher cost and CO_2 emission of electricity.

For none one family housing retrofit projects you can choose to use new defined demands for U-values, g-values and ψ- values instead. But since you will still need to use heat recovery ventilation as a demand it will in many cases be best for the builder and design group to work with the same energy frame values which is used for new built also in this case.

Since it is expected that use of heat recovery ventilation will be widespread used in connection to the new energy demands in Denmark there is also a new rule which states that municipalities can demand airtightness tests of new building projects, e.g. by help of a so-called blowerdoor test.

To be efficient in implementing the EU-energy performance directive for buildings in an effective way, and to be able to lead to aimed at energy savings in practice it has been proposed by the Danish Association of Sustainable Cities and Buildings that both building projects following the new minimum energy demands, and building projects which are made with an energy (+) standard should also include the “Energy-Quality” approach concerning performance requirements and follow-up which is described in Chapter 3.2.

2.3 "Energy Quality" Standard

As part of the total design budget for a building project an allocation of ½ % of the total building costs should be used for support on the following work:	1. Establishment of a clear definition of performance requirements for used technologies as well as for the complete building project. Here information in the Green Catalogue web site can be used as an inspiration (see: www.greencatalogue.com). 2. Monitoring and control of energy qualities and energy supply solution including use of blower door test, thermo photography and documented energy use including a monitored energy signature and green accounting after one year operation. In connection to items 1 + 2 a builder need to use an independent energy specialist organisation.	3. Use of Green Catalogue Questionnaire with energy and environmental points. And use of a certain number of sustainable building measures according to the Green Catalogue questionnaire. 4. Total economy assessment (optimisation of investment, operation and maintenance costs).	5. Assessment on adapted energy supply solution with reduced losses. 6. Assessment of possibility of utilising solar energy e.g. for domestic hot water or ventilation.

Figur 2.2

By help of the mentioned "Energy Quality" approach it should be possible to ensure that the difference between the calculated and monitored energy use for new and renovated building projects, which is normally between 20-40 %, should be much less in the future. Besides it can also help to create a good basis for the necessary energy labelling of buildings, so it can function in a trustworthy way.

In Denmark an initiative has been made to form a network of cities who will involve themselves in a "sustainable cities campaign" where means to obtain sustainable and energy efficient building will be developed and introduced in practice, also supporting the "EU-Thematic Strategy for the City Environment" KOM(2004)6039 to illustrate the relevance of this. From here can be quoted:

"In the EU countries only very few buildings are built or renovated in a sustainable way, even though there exist documented solutions for this. The main barrier is a lack of interest from the contractors and investors who believe that sustainable buildings are expensive and further they are suspicious of new technologies.

The long term benefits from sustainable building, like lower maintenance and operation costs, improved durability and a higher value for the building are not visible in the short term and in relation to the original purchase. Due to this it is needed to make a special effort to focus on such benefits, so investors, banks and mortgage banks will be able to spot the difference between buildings realised by normal solutions and sustainable buildings".

Examples on problems to obtain low-energy building in practice

Results of a monitoring campaign for 10 different multifamily housing estates in Malmö (Sweden) has been that especially the heating consumption was much higher than expected according to calculations.

The goal was that the average energy use should not exceed 105 kWh/m²a year covering both energy use for heating, domestic hot water (DHW) and common electricity use.

The overall result was 186 kWh/m²a for housing areas without heat recovery on ventilation and 127 kWh/m²a for housing areas with heat recovery ventilation.

Most housing projects reported 40-60 % higher energy use than reported by the developers.

The energy supply company, Sydkraft, counted on an energy use for heating of 70 kWh/m². a and electricity 35 kWh/m²a. See also annex 6.

District heating kWh/m², year

Light column: Calculated

Dark column: Monitored

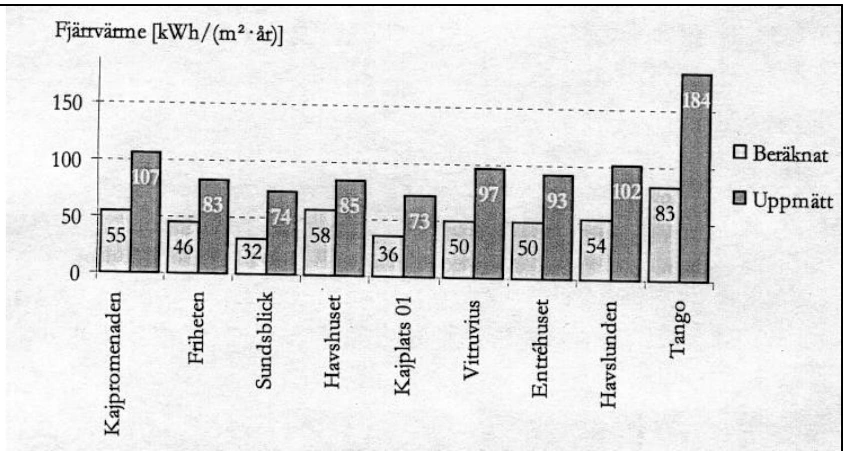


Fig. 2.3. Comparison between monitored and calculated energy consumption for 9 multi-storey low energy housing projects in Malmø at the BO-01 exhibition. The mentioned energy use is made higher than calculated for all the projects.

2.4 Proposed "Green Diploma" for new build and renovation in the housing area

The "Green Diploma" model, which is a labelling system for new build and retrofit housing, has been developed by Cenergia and Green guide Bettina Fellow, in co-operation with the Corporation of Danish Housing Associations, BL.

The "Green Diploma" model is suggested in 3 levels (A, B2 or B4), where level A is near to normal minimum demands, but demands an "energy quality control" and use of an "energy and environmental check list" as well as improved demands for U-values, g-values (for windows), ψ-values (line losses), water use and distribution losses. The B2 level is rated as a Green Low energy Diploma and includes more Low energy and environmental demands. And the B4 level is further improved with a demand to calculate an energy frame value like for new build and aim at a low energy class 2 quality.

The main areas of the "Green Diploma" are:

1. Introduction of an "Energy Plus" standard which is one level better than normal minimum demands. E.g. in Denmark low energy class 2 which is 25% better than normal.

2. Use of an "energy quality control" system for building projects.
   This includes: blower door tests, thermo photography and energy characteristics / energy signature together with a green accounting after one year of operation (including heat use, DHW use, electricity use etc.).

3. Use of "Green Catalogue" BAT sheets to ensure an energy quality which is better than normal for a number of technologies. (See www.greencatalogue.com).

4. Use of the "Green Catalogue" energy and environmental check list and point system.

5. Other areas:
   - Use of an adapted energy supply system with small losses
   - Avoidance of dangerous materials
   - Documented bio factor
   - Documented total economy
   - Building project prepared for use of solar energy

In a green accounting key figures for energy consumption in kWh/m2 is calculated for room heating, DHW and electricity use. Total water consumption is calculated in m^3. Besides calculation for solar energy is included in the green accounting.

The Green Diploma system is administrated by the Corporation of Danish Housing Association, see www.bl.dk or www.grontdiplom.dk.

In Annex VII there is a translated version of the Danish Green Diploma system for new build and renovation and in Fig. 2.4.1 there is an illustration showing one of the pages in this case concerning windows.

	Sfb No.	**A Minimum demands**	**B1 BR-demands for rebuilt and additions**	**B2 Demand on energy efficiency**	**B3 Improved environment al conditions**
Windows	**(28**				
			x)		
Similar to Green Catalogue:					
U-value (W/m²ºC):					
Frame		1,5	1,5	1,3	
Pane of glass		1,1	1,1	0,9	
Total		1,5	1,5	1,1	
g-value (W/m²ºC):					
Pane of glass		0,6	0,6	0,6	
Total		0,5	0,5	0,5	
Ψ-value W/m:		0,06	0,06	0,03	
Daylight optimisation in connection with choice of windows.					
The dwelling is					

optimises in preparation for utilisation of passive solar heat, with an account of how possible overheating problems have been solved.					
When changing windows. Energy efficient windows are installed.					
U-value for window including frame / window sill below 1,2 W/m²°C, check system for cold bridges.					
Windows are optimised regarding inflow of light and / or sunshading, documented.					
During renovation of windows existing windows are kept, however, an energy economic solution is though established e.g. by use of double windows or coupled windows.					- - - -

Table 2.4.1. Illustration of Green Diploma System for new building and retrofit housing here concerning windows. Demand for Minimum Standard (A), improved standard (B2) and use of environmental points is illustrated. (B2) is considered to be a Green Low Energy Diploma. This can be extended to a (B4) energy quality with an energy plus standard.

2.5 Green Quality Points

In Annex 2 there is a copy of the Green Build Questionnaire which also can be used to make a rating by help of energy and environmental points in areas like (A) water, rainwater and seawage, (B) indoor air climate, (C) materials and constructions, (E) energy and (F) building and urban development area.

2.6 Green Quality Evaluation - Performance verification procedures

In this chapter different Performance Verification procedures are presented.

2.6.1 Blower Door Test

The Blower Door test is designed to measure the air tightness of buildings and to find air leakage.

An air tight building is necessary to obtain low energy consumption and makes it possible to have control of the ventilation. Especially in buildings with mechanical heat recovery ventilation it is important to assure an air tight building. This will ensure optimal indoor air climate for the building users and at the same time save energy.

A Blower Door test can be made by mounting a fan (blower) in one of the exterior doors of the building, which blows the air in or out of the building. This creates a pressure difference between inside and outside, and will let air come in from all the holes and penetrations in the exterior envelope. In this way the air tightness of the building can be identified. All untight places in the construction can at the same time be located by help of smoke tests (figure 2.6.1.1) and use of a thermograph camera (Chapter 2.8).

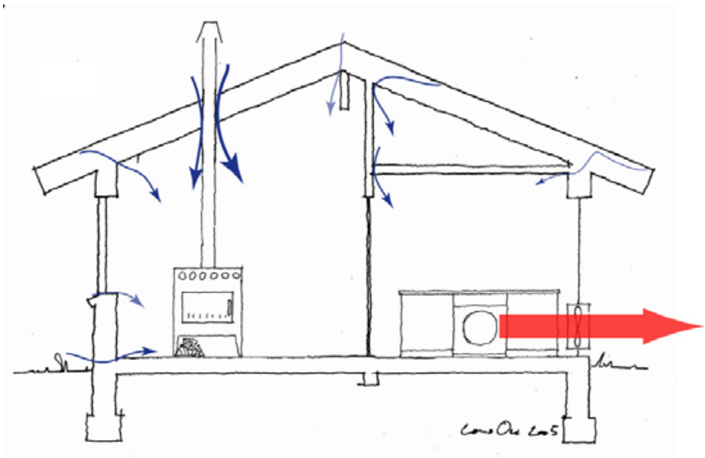


Fig. 2.6.1.1. A Blower Door blows the air out or into the building and creates pressure difference between inside and outside. Here is illustrated low pressure in the building.

Fig. 2.6.1.2. The smoke test helps locate the place which is not complete by airtight.

Fig. 2.6.1.3. Blower Door equipment with fan installed in one of the exterior doors of the building.

A depressurisation test creates a pressure difference of 50 Pa between inside and outside. 50 Pa pressure is almost equivalent to the pressure generated by 20 mph wind blowing on the building from all directions, and it is therefore most common to use this pressure difference to obtain a quick indication of the total air leakage in the building envelope.
With a difference in pressure of 50 Pa between the inside and the outside of a building the maximum air change should not be more than 2 times per hour according to the standards*. This has to be documented by measuring the air tightness of the building.

Special places to measure the air tightness by smoke test and thermography are:
- Connections between building components
- Installation penetrations
- Doorways and around windows.

The first test has to be carried out just after the completion or renovation of a dwelling. The test is carried out for each type of apartment and is carried out by the consultant for the owner. When the dwelling has become more air tight by recommended improvements made by the contractor so it performs according to the demands, then the tests are carried out again. Random checks should also be carried out when the building or renovation is finalised.

The air flow in m^3/h, that gives the pressure difference of 50 Pa between inside and outside, should be divided by the volume of the building to give the air change per hour at 50 Pa. When this air change again is divided by 20, it gives the average infiltration rate**.

The following method of conversion could be used for conversion of infiltration air change per hour at 50 Pa pressure difference:

$$n_{50}\ [h^{-1}]\ /\ 20,$$

where n_{50} is the air change per hour at 50 Pa difference in pressure.

Thus an air change of 2 h^{-1} at 50 Pa is equal to an average air change by infiltration of 0.1 h^{-1}.

**Reference: Minneapolis Blower Door TM, Operational Manual for Model 3 and Model 4 Systems, The Energy Conservatory, Diagnostic Tools to Measure Building Performance, Dec 2001.*

***Reference: Alan Meier, "Infiltration: Just ACH50 Divided By 20?" , Home Energy, July/Aug 1986.*

2.7 Energy Characteristic / Energy Signature

The Danish Energy Characteristic computer programme, which has been made in an Excel spreadsheet, is a programme for evaluation of energy performance and diagnostic of operation malfunctions. Here calculation is made both concerning the annual energy consumption and the pattern of the consumption expressed as W/m^2 vs. the ambient temperature (the heat characteristic).
By comparing the calculated and the measured characteristics it is possible to detect e.g. malfunction of automatic equipment, missing insulation, failures in the operation of the ventilation plants (after gaining experience with the use of the programme).

The programme was developed using Danish climate data with regard to ambient temperatures and solar radiation. In connection to the EU-Demohouse project were 17 climate zones in Europe included in total. For all climate zones the ambient temperature is for the location. The solar radiation, however, is only from Denmark (so far, but will be updated later to match the desired zone). The error from this is very limited concerning locations the northern part of Europe, but for southern Europe the error is considerably larger and will show energy consumptions that are too large, e.g. locations like Athens, Nice, Paris and Milan.

The calculation method is according to EN 832, but calculated with daily time steps. The ambient temperatures are represented by a sinus approximation, where the temperature is a function of the day number of the year.

Method for analysis

To state if the energy consumption wrongly is too high, the monitored consumption should be analysed and compared with a calculated consumption.

By analysis of the monitored consumption a heat characteristic is recorded where the heat consumption is expressed as W/m^2 versus outside temperature.
The expected consumption should be calculated and the result of the calculations is a record of a heat characteristic as well.

Firstly, standard values for the operation conditions are applied, e.g. an operation temperature of 20 °C and an air change of 0,5 /h. The building envelope is described by U-values and areas in m^2 (heat loss calculation). The orientation of the building is described, number of tenants is given and the technical installations are described by loss at idling and heating efficiency.

The calculation is for 24-hour with the outside temperature and sun inlet through windows expressed as a sinus approximation versus number of the days in the year. This is converted into gross energy consumption, so that the calculated consumption can be compared with the monitored consumption.

If the calculated heat characteristic is identical with the monitored, the consumption is reasonable and there is no need for further analysis. However if the monitored consumption exceeds the calculated consumption, further analysis are made to find the reason for difference. By adjusting the application parameters (inside temperature, air change, idling loss / circulation pipe loss, etc.) the changes are made until the two characteristics are identical.

The calculation programme includes the possibility for variation of each parameter during the year, e.g. the air change is typically less as lower the out side temperature is.

The result of the calculation programme is a presentation of the average requirement for power compared with the out side temperature. This can also be expressed as the relative heat requirement (in proportion to the design heat requirement) compared with the outside temperature.

Dalgasparken, DENMARK

Below is shown some results on measurements of heat consumption versus the ambient temperature in an apartment building located in Dalgasparken in Herning, Denmark for 5 different types of apartments (see fig. 2.7.1). These apartments were built according to the Danish Building Regulation from 1995.

The estimation of heat consumption was made from 15th of Jan. 2004 – 15th of Aug. 2004.

Fig. 2 below shows calculation results for the following 5 situations:

1. Average for whole building
2. Apartment located in middle of the building on roof floor
3. Apartment located in gable on roof floor
4. Apartment located in middle of the building in middle floor
5. Apartment located in gable in middle floor

The measured consumption are based on readings of energy meters placed in each apartment. The average consumption is calculated for the total building envelope and the total amount of tenants.

The average consumption is based on the sum of the consumption of apartments and does therefore not include heat loss from supplying pipes from district heating connection in the buildings basement to each of the apartments.

In the example there is only made one single measurement of the consumption in the period from 15. Jan. 2004 – 15. Aug. 2004. The middle effect for each of the 33 apartments is plotted to a (corrected) average out door temperature for the period. The correction of the out door temperature is made to take into consideration the non-linear course of the heat characteristic during the transitional period.

There are in total 18 apartments, which have a consumption that is larger or less than this band of expected consumption. Among the apartments with over consumption (9 units) there are 5 which have a consumption above 2 W/m^2 more than the prospective with the most exposed location.
There are potential possibilities for errors in these apartments for errors in installations, insulation or leak.

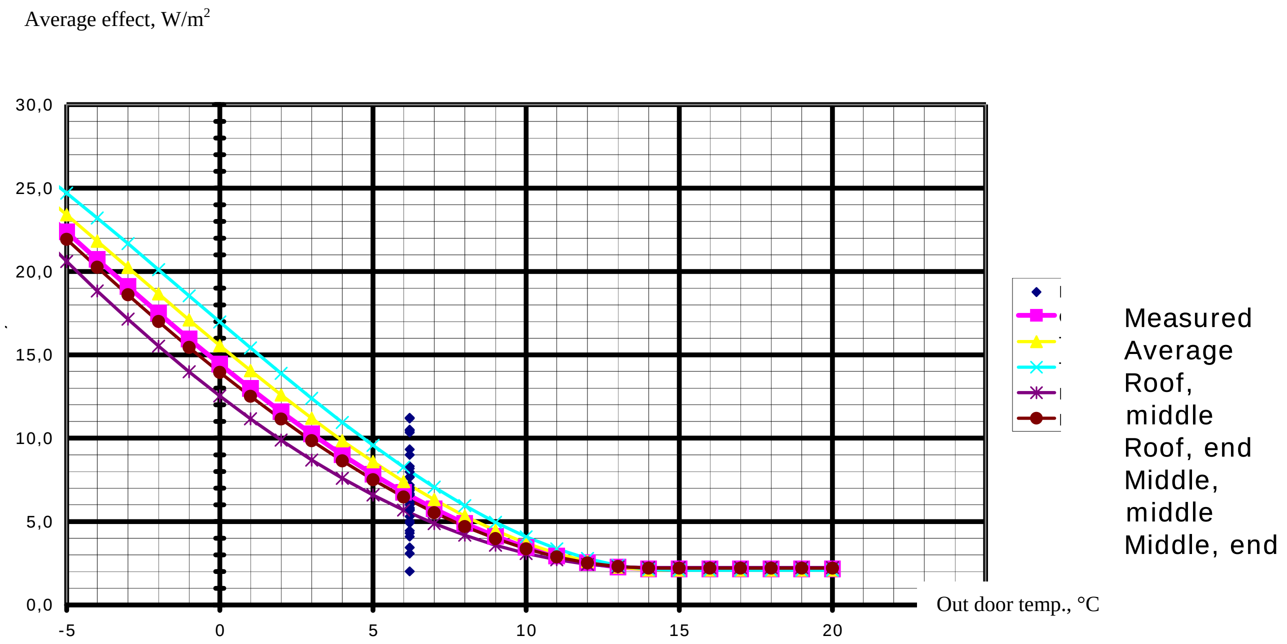


Fig. 2.7.1. Measured heat consumption inserted in energy profile diagram.

The following conclusions can be drawn:

1. The variation in measurements shows the large effect of user behaviour on energy consumption
2. The average of the measurements agrees with the calculated energy consumption
3. For conclusions regarding the slope of the line in fig. 2.7.1., more measurements (at different ambient temperatures) should be carried out. This is currently the case in Dalgasparken.

When comparing the calculated signature with the measured one, usually a difference is observed between the two. The procedure is to modify parameters in the excel-tool (ventilation rate, transmission losses, indoor temperature etc.) until the calculated and measured signatures agree. Differences are usually due to user behaviour (too high indoor temperature, etc). These parameters can be adjusted in a separate sheet (user data) in the tool. Conclusions can be drawn from the difference in 'design values' and 'best fit' values.

Fig. 2.7.2. below illustrates an example of the calculated heat consumption of an average apartment of 105 m^2, over a time period of 24 hours.

24 h period consumption, kWh

Dalgasparken
Heat consumption for average apartment of 105 m^2

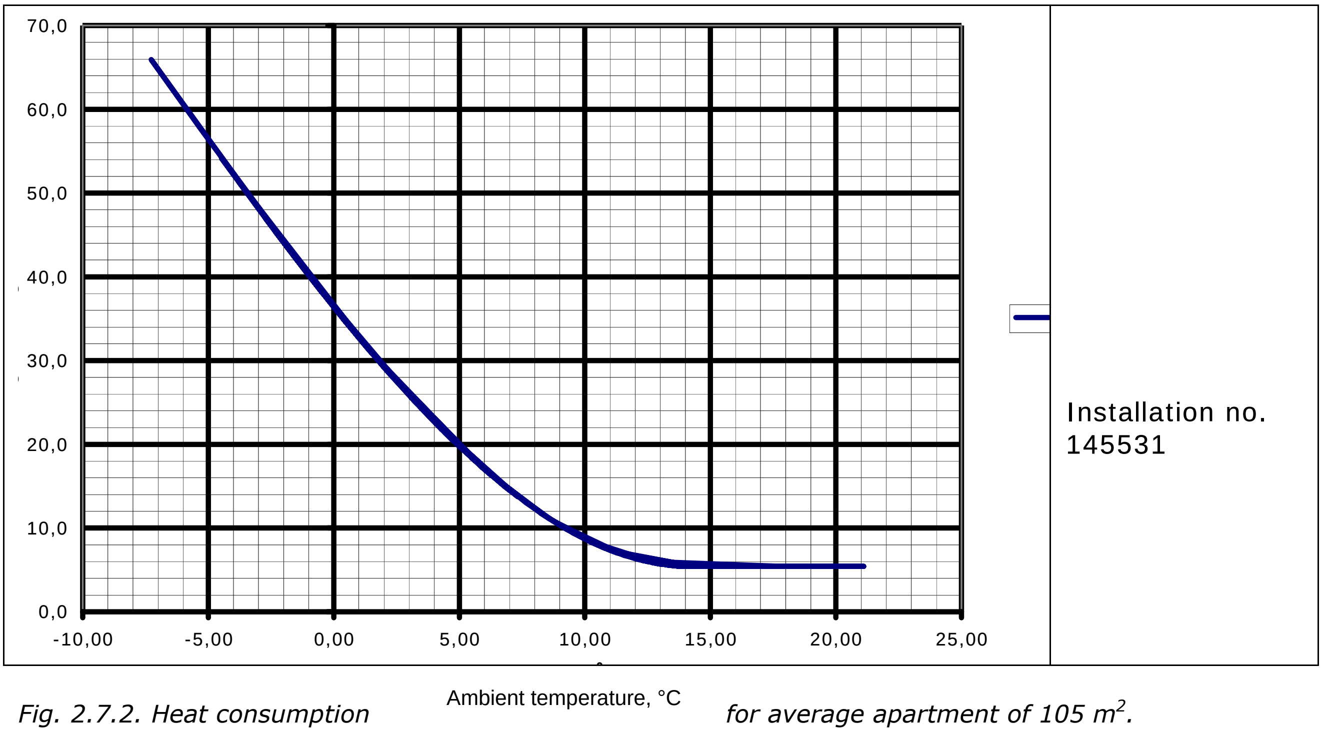


Fig. 2.7.2. Heat consumption for average apartment of 105 m².

Examples

The method described above was applied successfully in a number of projects. In one particular project, the summer energy consumption was much higher than the maximum value of 5-6 W/m² (for DHW). This could be attributed to a water temperature from the boilers that were much too high.

Another example was the energy consumption in a project in Poland, where the energy consumption did not depend on the outside temperature (a horizontal energy signature). In this case, the occupants simply opened the windows to cool the building (even in wintertime).

Yet another example is about an average multi-floor residential building block of approx. 1.200 m² in Glostrup, Denmark. The total estate includes approx. 30 three-floor building blocks. The estate is built around 1995 and is supplied with district heating. There is only one heat meter for the whole estate this means that the measured and the calculated energy consumption also includes heat losses from distribution pipes between the housing blocks.

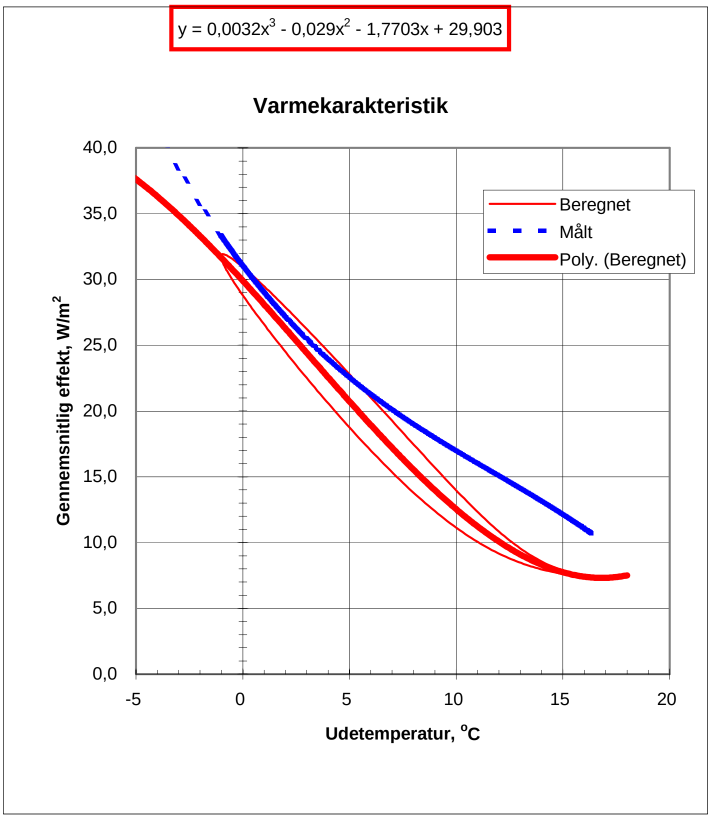


Fig. 2.7.3. Example of a heat characteristic for a multi-floor building. The red curve is calculated and the blue curve is measured.

The curves are quite identical when the outdoor temperature is between 0 °C and 5 °C. By higher out door temperature the blue curve exceeds the red one and there is a significant over consumption. For example, there is measured an average effect consumption of approx. 12 W/m^2 by an out door temperature of 15 °C. The calculated consumption at this out door temperature is approx. 8 W/m^2. The over consumption of approx. 4 W/m^2 is probably due to a wrong adjustment of the automatic control equipment.

For an average apartment of 70 m^2 the over consumption is approx. 280 W as middle effect. This is equal to an additional consumption of approx. 7 kWh per day – or 600 kWh in the summer months. The total estate could save approx. 100.000 kWh or 50.000 DKK per month by better adjustment of the temperature level in the heating system.

More information on the energy signature system can be found in Annex I where a copy of a special developed excel spreadsheet is presented.

2.8 Thermography

One of the best ways to find cold bridges in buildings is by taking a thermograph picture with an infra red camera, which can be done both in new and old buildings.

Thermography is a special way of infrared photography where different colours in a picture show the temperature of each object. In this way hot and cold parts of a building can be visualised.
The picture shows the heat radiation and documents if the existing insulation is good enough, and where there are holes etc.
It is also an effective method to show moisture damages, especially in old buildings.

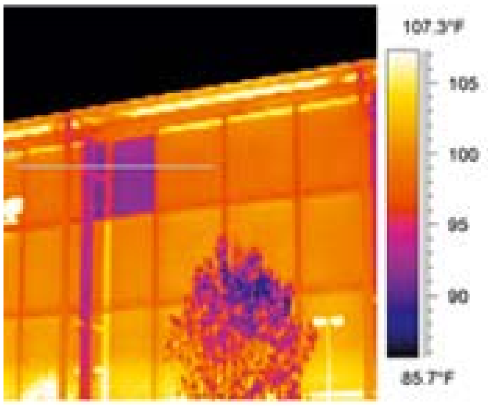


Fig. 2.8.1. Infrared picture taken of a building from outside with a thermograph camera.

The two pictures below show a part of a building construction from inside, where heat loss through joint between floor and wall can be seen by darker colour in the picture taken by the infrared camera.

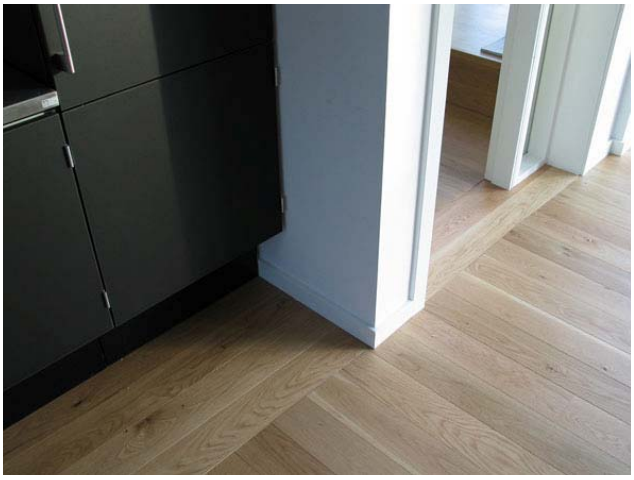
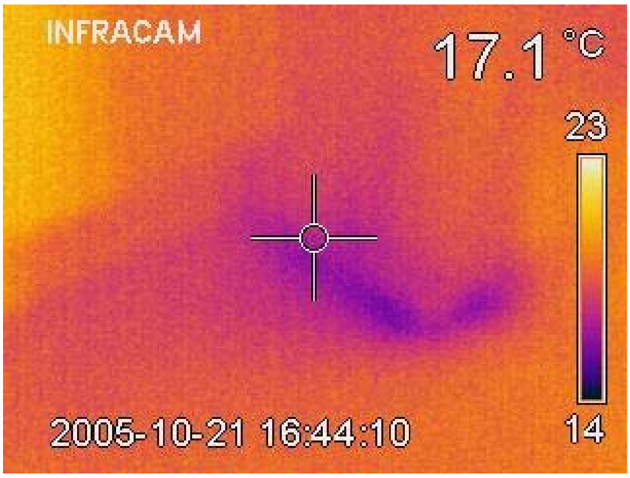


Fig. 2.8.2. Picture of the wall and floor in CO2 neutral roof top apartment used for retrofit of old housing blocks.



IR-picture of the same geometry, showing thermal bridges at the joint between wall and floor.

2.9 Implementation of Green Quality Building Process for Danish reference Project Gyldenrisparken

In Denmark it has been possible to show very high energy savings and good operation results from use of heat recovery ventilation in new built housing projects (see fig. 4.1).

It has here been possible to document up to 50 % savings in practice when heat recovery ventilation is combined with airtightness of housing units.
Besides low extra installation costs around 1.100 – 1.300 Euro per housing unit have been documented.

This also includes the development of a CO_2 neutral rooftop apartment, as an extra storey in connection to renovation of concrete housing blocks with flat roofs (see www.soltag.net).

There also exist several Danish demonstration projects where heat recovery ventilation has been introduced in retrofit housing projects in connection with use of solar energy (see fig. 3.1.1.4).

These projects have all shown problems of how to achieve a satisfactory air tightness of the housing units when you are dealing with existing housing blocks.

However, for concrete housing blocks with an extensive renovation this should be possible. So this is one of the most important challenges of the EU-Demohouse local demonstration projects in e.g. Denmark, Hungary and Poland. More information on the CO_2 neutral rooftop apartment can be found in Annex 4, and in Annex 5 there is more information on the consequences of the new energy rules in Denmark.

Proposed heat recovery ventilation design for retrofit housing projects

In co-operation with the Danish ventilation company EcoVent development work has been made concerning use of an only 22 cm thick heat recovery ventilation (HRV) unit which can both be integrated in connection to a partition wall in a vertical position as well as installed above a suspended ceiling.

The main focus has here been on obtaining a very low electricity use for the fans, a low noise level and an easy way of installation.

EcoVent has during the last couple of years developed a completely new HRV-heat exchanger which has been monitored to have efficiency in a dry HRV test of 89% while the SEL value is below 800 J/m³ (compared to new demands in Denmark of 1.250 J/m³). Besides the heat exchanger is 40 cm shorter than the old versions.
This makes it possible e.g. to install the HRV unit over a suspended ceiling in e.g. a small existing bathroom (HRV unit length 1.3 m). (see also www.ecovent.dk)

At the same time the low electricity use around 240 kWh per year can be matched by only 0.3 kWh or 2-3 m² PV panels on a yearly basis.
Based on this it is the aim to be able to show an economy for retrofit housing HRV installations which is similar to new built.

Fig. 3.1.1.1.: Illustration of an only 22 cm thick heat recovery ventilation unit which can be integrated in a partition wall or placed over a suspended ceiling, in both new build and retrofit housing projects.

Low energy housing for 72 housing units in Dalgasparken , Herning

PV panels used to match electricity use for ventilation

Fig. 3.1.1.2.

Dalgasparken :
Use of airtight construction and heat recovery ventilation lead to a 50% saving of the heating bill – compared to normal

Low energy housing project with 17 prefabricated dwellings in Solengen, Hillerød

Roofs prepared for PV.
A new type of Sarnafil roof with PV used for common house.

Solengen, Hillerød

An only 22 cm thick heat recovery ventilation unit (EcoVent) is integrated in partition wall between bathroom and entrance area.

Solengen, Hillerød

Airtight constructions made by ScandiByg were checked by help of a blowerdoortest

Prefabricated CO_2 neutral rooftop apartment (JYTAS) with HRV, solar DHW and PV panels is exhibited in Ørestad Nord, Copenhagen.
(www.soltag.net)

Fig. 3.1.1.3. Good reference examples from Denmark concerning energy efficient housing projects, using balanced heat recovery ventilation in combination with PV to match electricity use for ventilation.

Fig. 3.1.1.4. Low energy retrofit housing project at Østerbro, Copenhagen, Individual HRV units in each apartment and preheat of ventilation air in solar wall to the south.

In fig. 3.1.1.5, 3.1.1.6 and 3.1.1.7 are shown examples of low energy retrofit housing projects in Denmark with use of balanced heat recovery ventilation in combination with solar preheating and PV modules to match electricity use for ventilation.

Fig. 3.1.1.5. Low energy retrofit housing at Lineagaarden, Frederiksberg in Copenhagen. PV is matching energy use in shared HRV systems for 200 housing units.

Fig. 3.1.1.6. Air solar collector with PV modules at Lauritz Sørensens Gård, Frederiksberg, Copenhagen. Ventilation air is here preheated before entering HRV systems.

Fig. 3.1.1.7. Test of different types of HRV systems in combination with PV to match electricity use for ventilation at a low energy retrofit housing scheme in Lundebjerg, Skovlunde near Copenhagen.

2.10 Performance Verification Procedure in the Danish pilot project

2.10.1Airtightness measurements

In the Danish pilot project in Gyldenrisparken blowerdoor tests have been made to ensure that a good airtightness can be reached. In fig. 3.2.1.1. is shown photos from the bloverdoor tests which showed that it was possible to reach a good airtightness in practice.

Fig.3.2.1.1. Blowerdoor test in Gyldenrisparken

2.10.2 Thermography in Gyldenrisparken

In fig. (3.2.2.1) is shown results of the thermography in Gyldenrisparken. This illustrates the need to insulate heat distribution pipes in the apartments and to avoid cold bridges at the new window constructions.

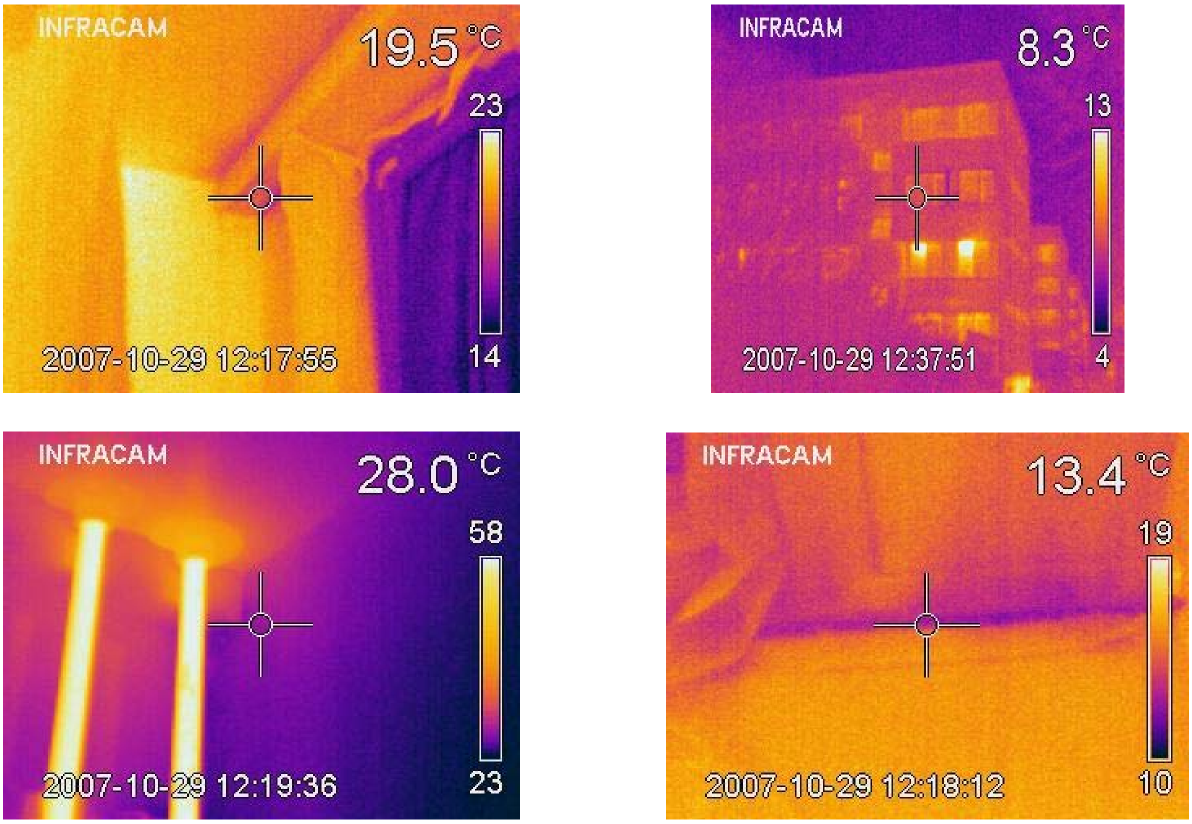


Fig. 3.2.2.1. Thermography of existing building

2.10.3 Energy signatures in Gyldenrisparken

In fig. (3.2.3.1) is illustrated the energy signatures made for the existing buildings in Gyldenrisparken. Here was used the Excel tool made for Demohouse where a calculated energy signature for the pilot project can be directly compared to the monitored results.

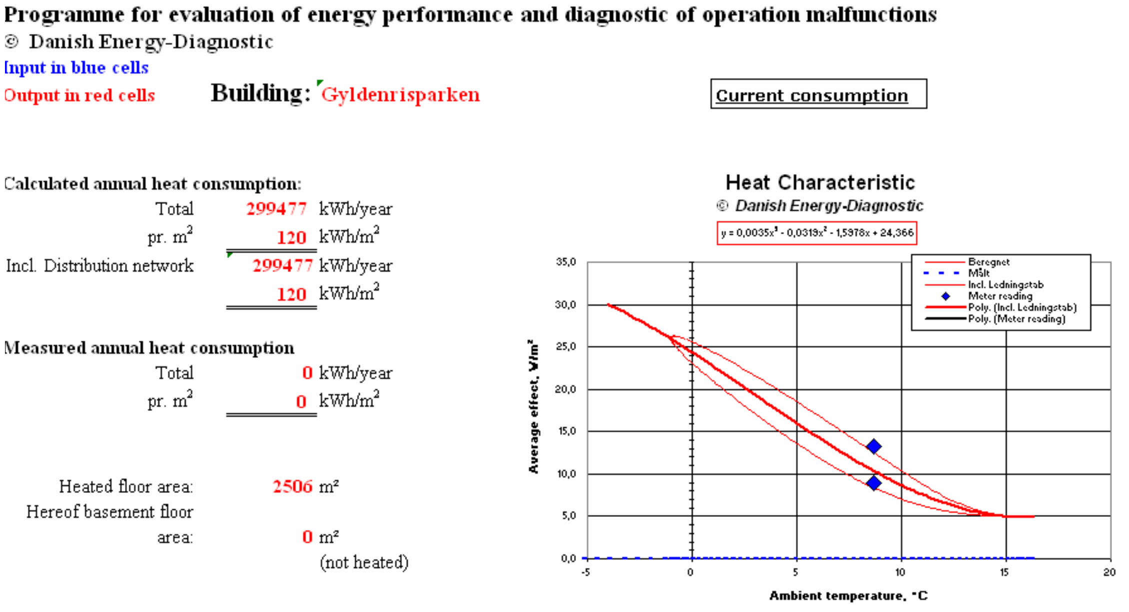


Fig.3.2.3.1. Energy signatures from Gyldenrisparken.

ANNEX I

Dansk Energi-Diagnostik
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DK - 4000 Roskilde
Denmark
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Mobil Phone: +45 23 47 26 44,
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1.1.1 CVR-nummer:

Programme for Evaluation of Energy Performance in Buildings and Diagnostics of operation malfunctions.

User Guideline

June 2007

Introduction

The programme is an Excel spreadsheet. When the programme is opened in Excel, Data of a building in Denmark is presented.

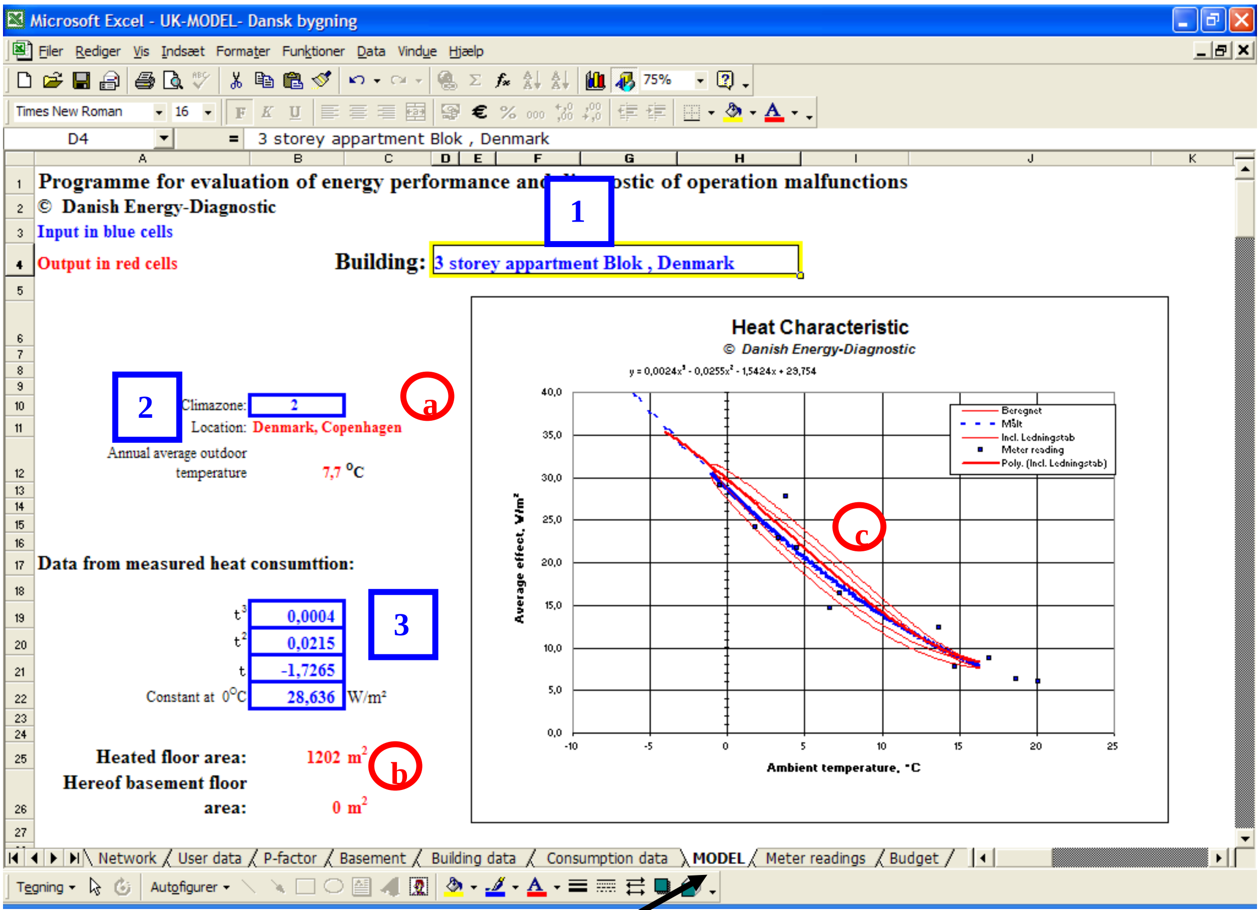
When data for other buildings are to be analysed, simply overwrite the existing data and save the new data by using another name and path – and so on with the next buildings.

The current programme is using Danish climate data with regard to ambient temperatures and solar radiation. There are included 17 climate zones in total, please refer to page 12 for the ID number for each location included. For all climate zones the ambient temperature is for the location. The solar radiation, however, is only from Denmark (so far, but will be updated later to match the desired zone). The error from this is very limited concerning locations the northern part of Europe, but for southern Europe the error is considerably larger and will show energy consumptions that are to large, e.g. locations like Athens, Nice, Paris and Milan.

The calculation method is according to EN 832, but calculated with daily time step. The ambient temperatures are represented by a sinus approximation, where the temperature is a function of the day number of the year.

The main result of the calculations is both the annual energy consumption and the pattern of the consumption expressed as W/m^2 vs. the ambient temperature (The Heat Characteristic). By comparing the calculated and the measured characteristic is possible to detect e.g. malfunction of automatic equipment, missing insulation, failures in the operation of the ventilation plants (after gaining experience with the use of the programme).

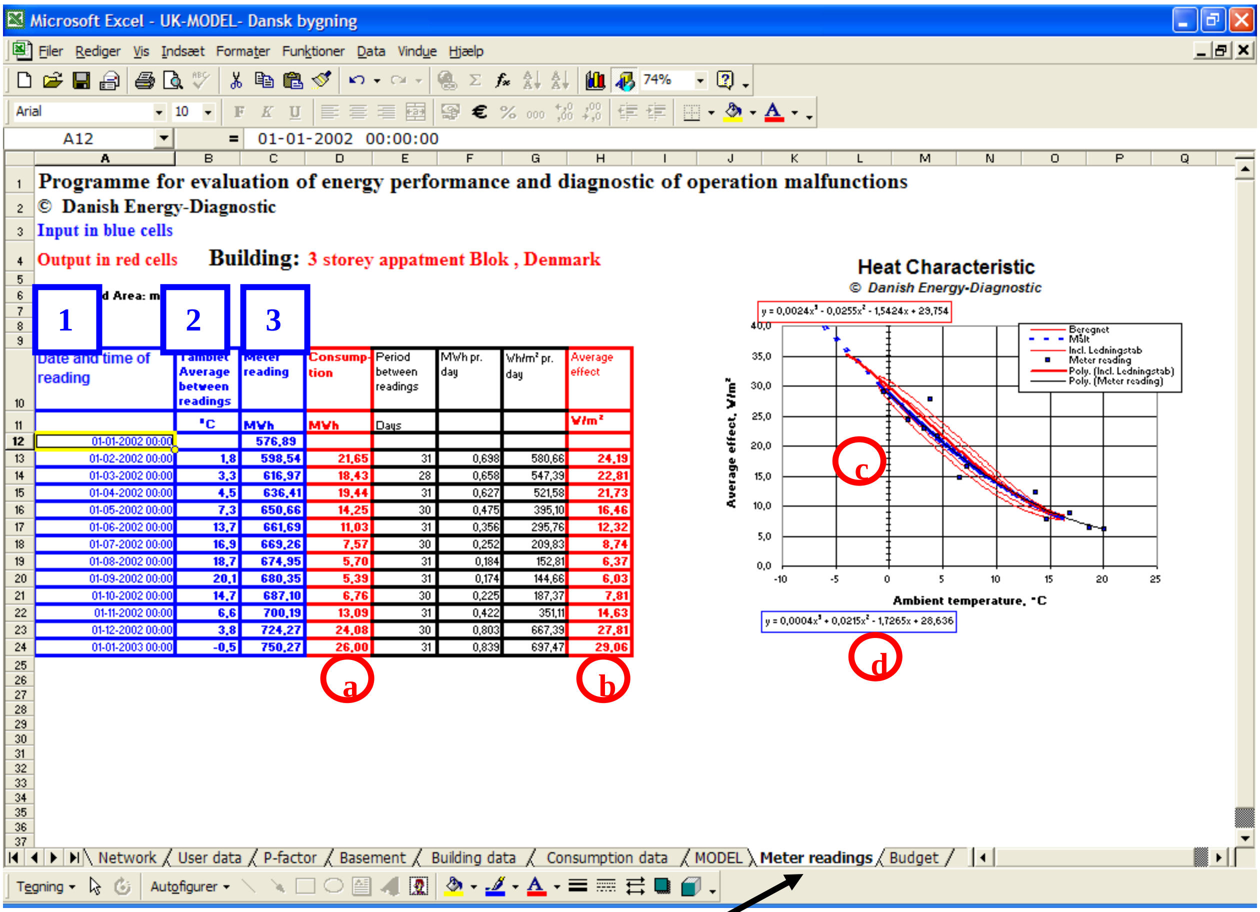
It is possible to change values in blue cells; all other cells are protected and cannot be changed.



Guide tap:

Model

Input	Output
1) Identification of the project 2) Identification of the climate zone of which the ambient data are used in the calculation. 3) The constants from a regression analysis of measured data (see guide tap "Meter readings"). The polynomial of power 3 and the measured data are indicated at the graph of "Heat characteristic".	a) Confirmation of the name of the climate zone location and the mean annual ambient temperature of the location. b) Information on the size of the heated floor area and the area of the basement. This is to confirm the size of the building that has been defined under guide tap "P-factor". c) Heat characteristic, measured and calculated. The measured dataset are shown on this graph.

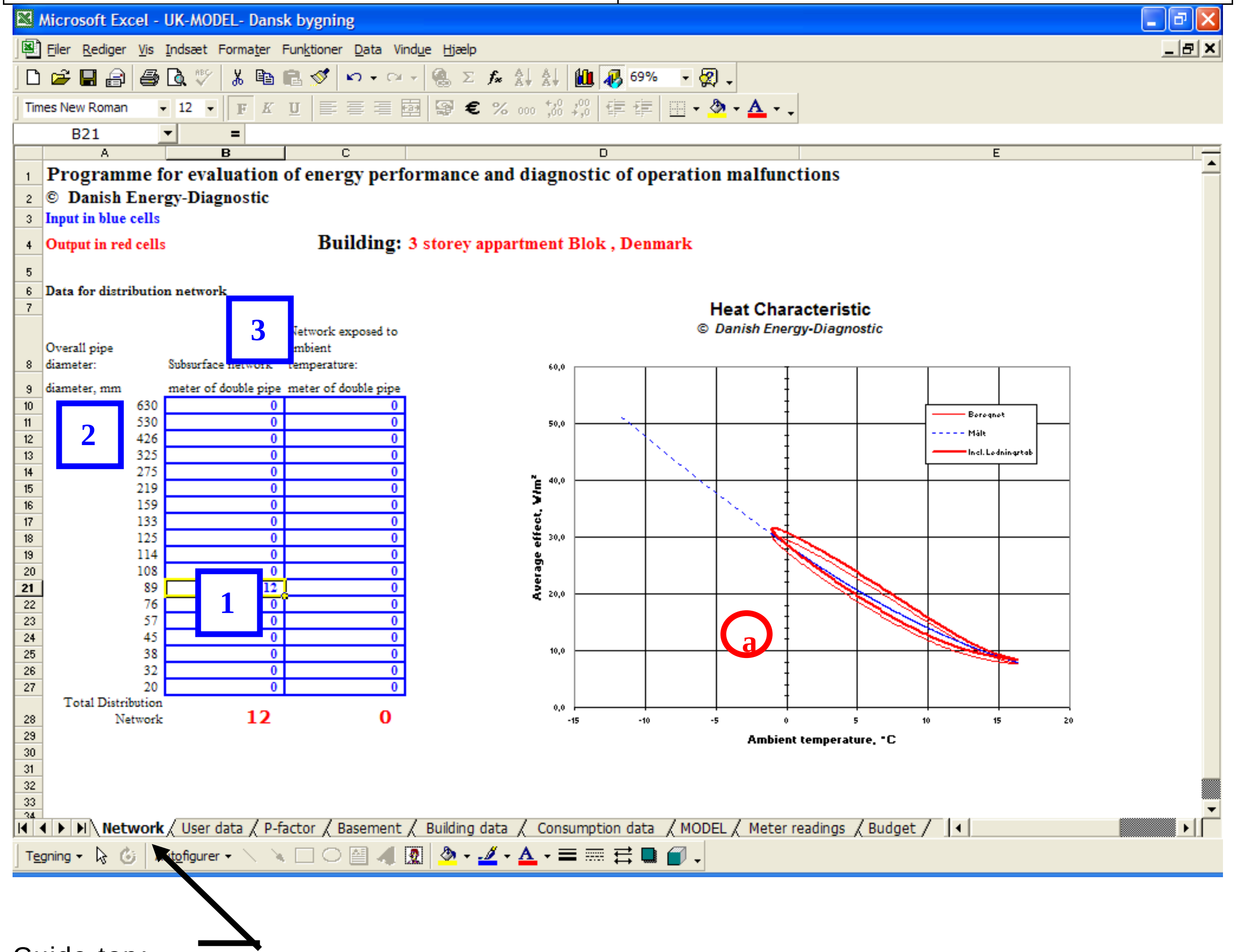


Guide tap:

Meter readings

Input	Output
1) Date and time of meter readings. 2) The average ambient temperature during the period between two-meter readings. 3) The meter reading (in this version the energy unit is MWh, if GJ is used it is necessary to convert to MWh).	a) Heat consumption during the period b) The average effect (W/m^2) during each period. c) The heat characteristic. The graph contains information on the calculated and the measured characteristic. Further, the graph shows the measured dataset, the average effect vs. the outdoor temperature. d) The formula for the polynomial of power 3, to be used in the Guide tap “Model” In the current version, the constants have

	to be transferred manually to “Model”.

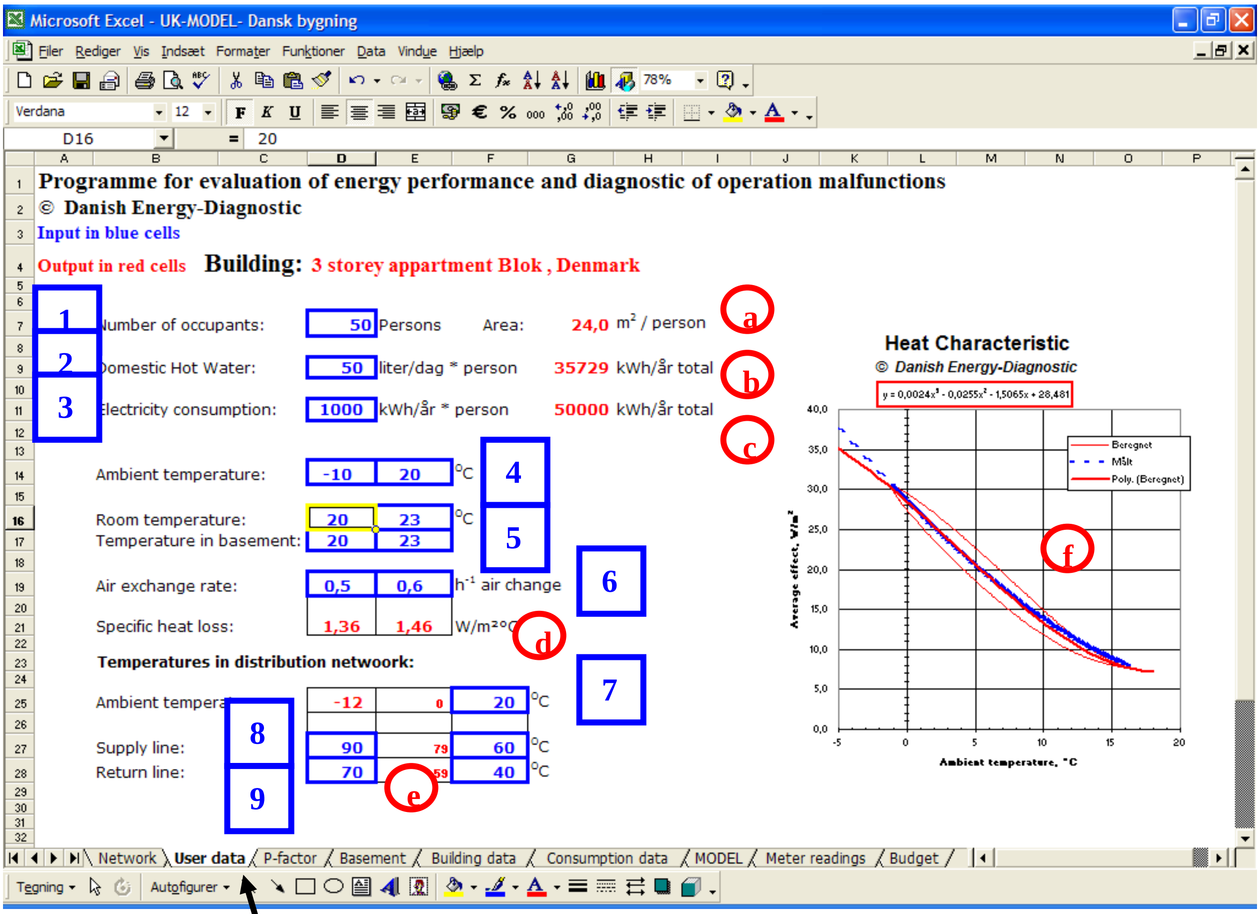


Guide tap:

Network

Input	Output
Definitions of distribution network outside the building, e.g. a district-heating network connecting a boiler house to the building. Indicate: 1) Length of pipe for each of the used dimensions. 2) Diameters of pipes 3) Location of pipes: underground or above ground. It is acceptable to use both locations and several diameters.	a) Heat characteristic, measured and calculated. The heat loss from the distribution network is the difference between the two red curves on the graph.

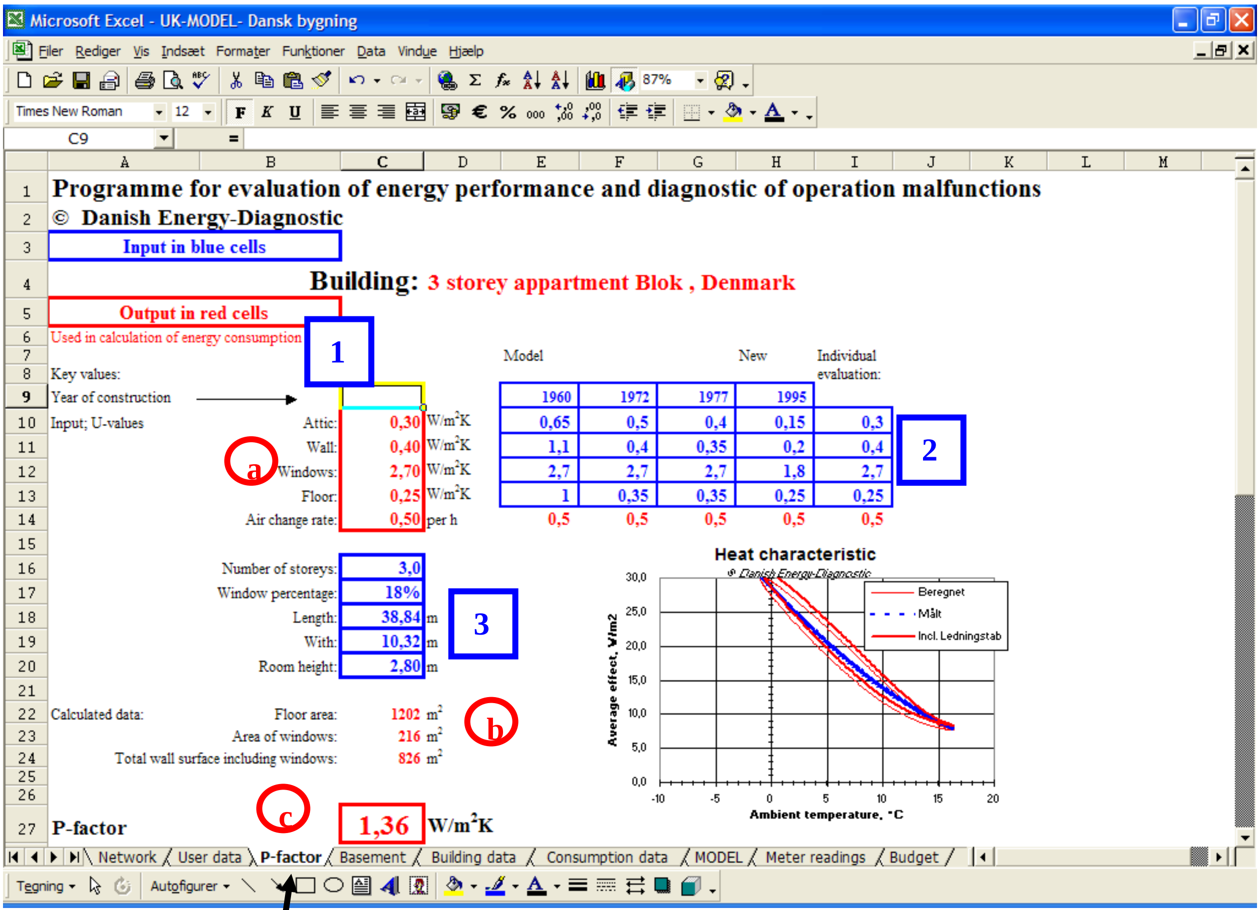
In the example, 12 m of 89 mm underground pipes are indicated.	



Guide tap:

User data

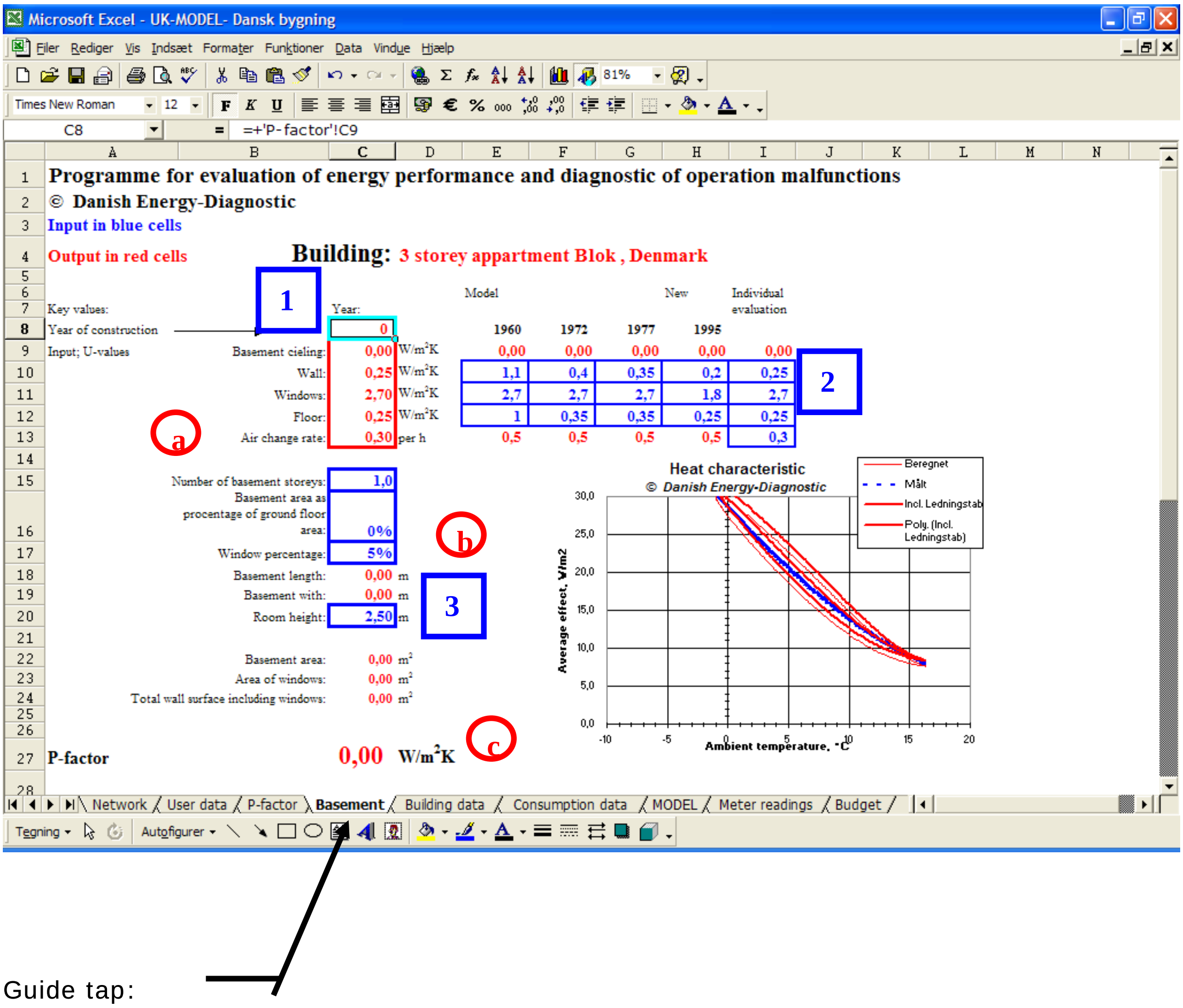
Input	Output
1) Number of occupants of the building 2) Consumption of Domestic Hot Water in liters per day per person. 3) Annual electricity consumption per person. 4) Ambient temperatures at which the indoor temperatures and air exchange rate is evaluated. 5) Indoors room temperatures. 6) Air exchange rates 7) Ambient temperatures at which the water temperature in the distribution network is indicated. 8) Temperature in the supply pipe 9) Temperature in the return pipe.	a) Heated area per. Person b) Total annual heat consumption of Domestic Hot Water. c) Total annual electricity consumption. d) Specific heat loss from the building [W/m^{20}C] calculated for each of the indicated air exchange rates. e) Distribution network temperatures at 0 ^{0}C outside. f) Heat characteristic graph.



Guide tap:

P - factor

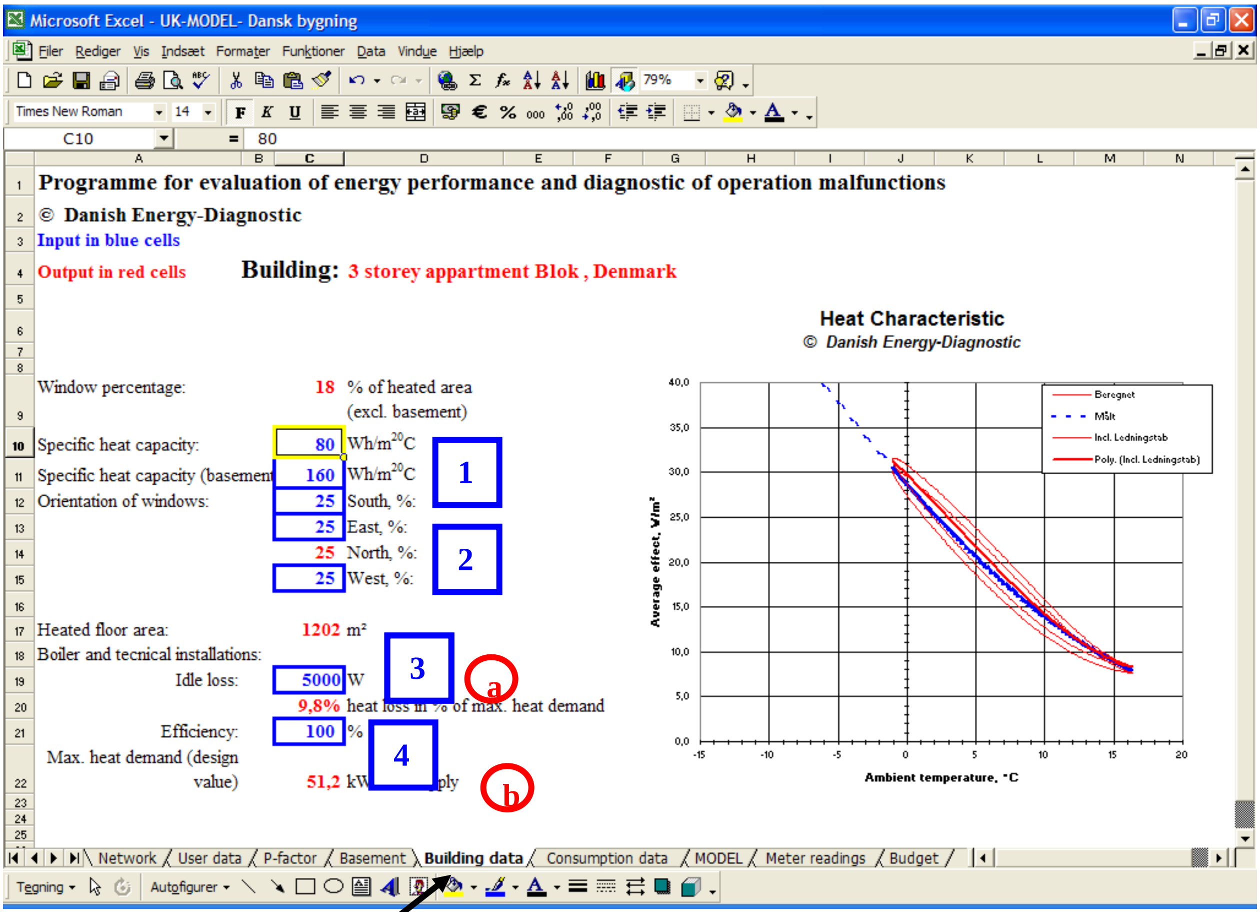
Input	Output
1) Year of building construction. If empty, the U-values for individual evaluation will be used. If filled with a year of construction, using the U-values in force at that year we will use the U-values in the table. 2) U-values in force at a given year. 3) Size of building: Number of stories, Window percentage (Window area in percent of floor area), Length and With of building, and room height.	a) The U-values used in the calculations. b) Some key values of the building size. c) The Specific Heat loss of the building in W/m^{2}K (per m^2 of heated floor area, using the lowest ambient temperature as indicated in Guide tap “User data”.



Guide tap:

Basement

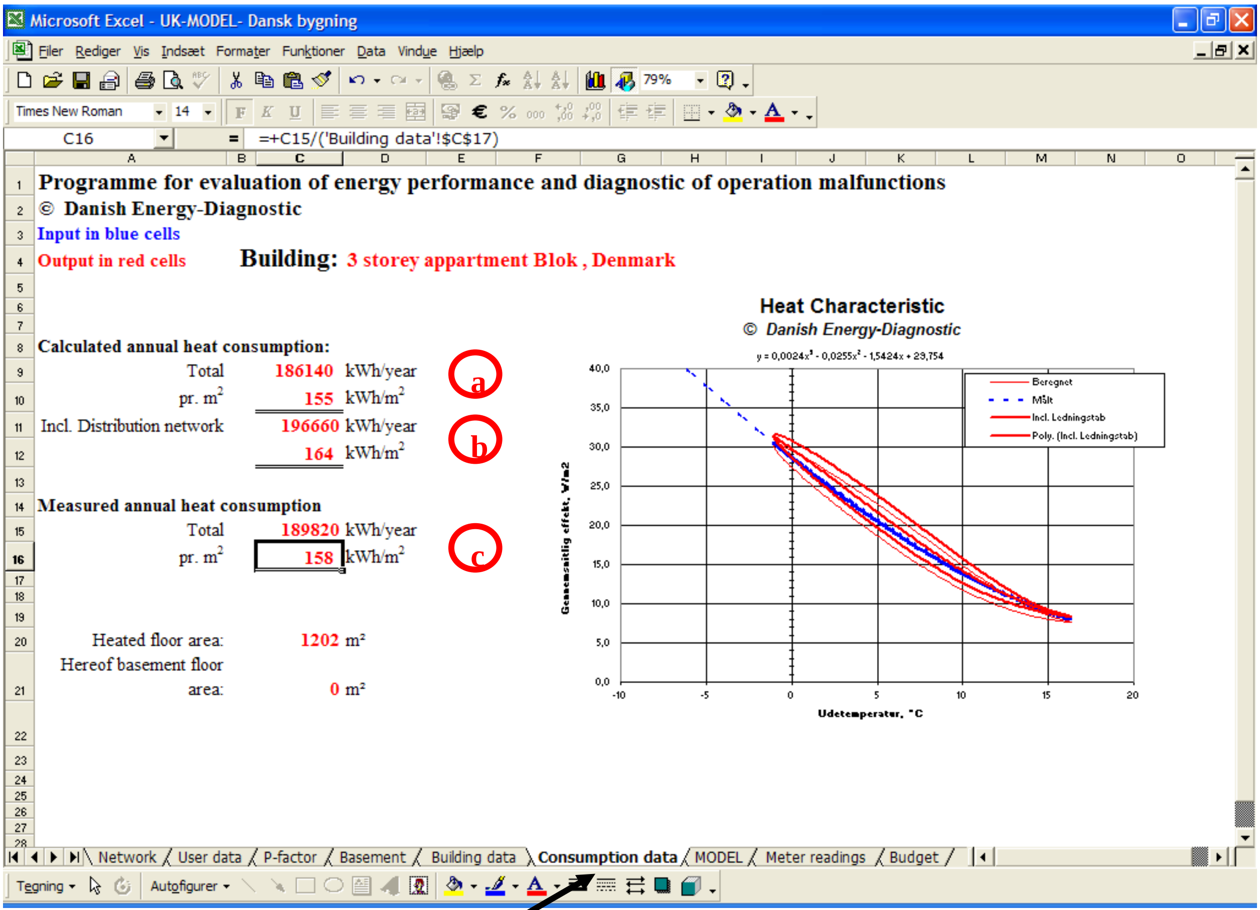
Input	Output
1) Year of building construction. If empty, the U-values for individual evaluation will be used. If filled with a year of construction, using the U-values in force at that year we will use the U-values in the table. 2) U-values in force at a given year. 3) Size of building: Number of storeys, Basement as a percentage of the ground floor area, Window percentage (Window area in percent of floor area), and room height.	a) The U-values used in the calculations. b) Some key values of the basement size. c) The Specific Heat loss of the basement in W/m^{2}K (per m^2 of heated basement floor area, using the lowest ambient temperature as indicated in Guide tap “User data”.



Guide tap:

Building data

Input	Output
1) The heat capacity of the building and the basement 2) Orientation of Windows (indicate the percentage for each direction. Direction North is the remaining part after stating the other directions. (as a remainder of the total window area). 3) The idle heat loss from boilers and technical installations (estimate as a constant heat loss during the year). 4) Efficiency of the boiler (100% - the conversion loss in %),(if district heating, the efficiency will be 100%)	a) The idle heat loss as a percentage of the maximum heat demand. b) The maximum heat demand, expressed as fuel supply.



Guide tap: ——

Consumption data

Input	Output
	a) The Calculated annual heat consumption in total and per m². (Excluding the heat loss from the distribution network). b) The Calculated annual heat consumption in total and per m². (Including the heat loss from the distribution network). c) The Calculated annual heat consumption in total and per m². Based on the Meter reading data and extended to represent a normal year (Including the heat loss from the distribution network).

ANNEX II

Questionnaire about sustainability measures for new or existing buildings and urban development areas.

Guidelines for the use of the questionnaire

The „Green Build“questionnaire is based on the Danish developed Green Build Tool, which works as an „energy and environmental point system“. It has for example been used in the EU „Energie“ supported project, „Green Solar Regions“, where it was used in connection to a new urban development project with individual houses and apartment blocks for around 800 inhabitants in the municipality of Glostrup in Denmark. Here it is also being used for new building and retrofit projects in the municipalities of Roskilde and Copenhagen.

The Green Build tool has been developed by Peder Vejsig Pedersen from Cenergia in cooperation with architect Klaus Boyer Rasmussen from SolarVent. An interactive version of the Green Build questionnaire exists in the website www.greenglobal21.com (www.plinio.dk/green), which is operated by SolarVent.

In Glostrup the Green Build questionnaire was used by the municipality which asked interested builders to fill in the questionnaire when they were bidding for land. The aim was to identify a way to monitor energy efficient and sustainable building measures and to initiate a work that utimately could lead to a standard evaluation method in new and retrofit building projects.

The Green Build questionnaire is part of the so-called Green Build tool, which shall make it possible for European municipalities to assess and compare their individual environmental performance. It is here possible to work with the questionnaire concerning sustainable building measures in general. It can also be used by municipal authorities and builders who want to document sustainability in their own building and planning projects.

The answering of the questionnaire is divided into two phases. One phase for what is the intention to do, and another phase is telling what is the aim to do, just before the building project starts, when the final economy is known.

Phase 1 is thus what the building owner intends to do with his building from the beginning.

Phase 2 is about what the builder intents to do just before the building project starts, when the economy is know. Can e.g. be delivered to the municipality in connection to the application for a building permit.

When energy and environmental points are attached to the questionnaire, then the achieved number of energy and environmental “points” in 6-7 different areas can be used to identity a rating between A and M which can be compared to aimed at local standards. To motivate sustainability measures and improved financing based on achieved point levels can be an efficient promotion tool.

The questionnaire is filled in by ticking off the questions which [are intended] / [will be fulfilled]. For example regarding energy savings. If the energy consumption is below for example 32 kWh/m^2 all 3 lines should be ticked off as shown below:

☑ Energy consumption for heating is below 46 kWh/m^2
☑ Energy consumption for heating is below 40 kWh/m^2

☑ Energy consumption for heating is below 35 kWh/m^2

In other words: The fully filled in questionnaire will be a picture showing the degree of agreement between the original intentions and real facts in the project that will be realised.

Green Build questionnaire, including suggestion for "energy and environmental points" [ ]

A) Water, rainwater and sewage

	PHASE1	PHASE 2
1. Water saving toilets with differentiated flush is installed (3/6 litre) [1]	☐	☐
2. Rain water collection for garden irrigation is installed [1]	☐	☐
3. Water saving taps are installed: Toilet-sink max. 6 l/min., kitchen-sink max. 12 l/min. and shower max. 12 l/min [1]	☐	☐
4. A main water metering device is installed at each main plot of land (for use in main green accounting) [1]	☐	☐
5. Measures that minimise amount of rain water collected by the sewage system are carried out (permeable pavements, rain water ponds etc.) [1]	☐	☐
6. Rain water collection for use in washing machines is installed [2]	☐	☐
7. Rain water collection for use in toilet flushing is installed [3]	☐	☐
8. Washing- and dishwashing machines with minimised water consumption are installed [1]	☐	☐
9. Thermostat-mixing tabs of a type which can be serviced without the installation is opened is installed [1]	☐	☐
10. "Grey" wastewater is utilised 1) [4]	☐	☐
11. Individual water meters installed [1]	☐	☐

Building owner's suggestions for other measures within " Water, rainwater and sewage": ____

B) Indoor air climate

	PHASE 1	PHASE 2
1. Air tightness of the building is measured to be less than 0.1 per hour [2]	☐	☐
2. Noise from installations is kept below 25 dB. [3]	☐	☐
3. Daylight optimisation [3)] is performed and documented [2]	☐	☐
4. Passive solar energy design is applied. How the problems with overheating are coped with so the indoor temperature is not exceeding 26°C. Is documented [2]	☐	☐
5. In-door materials with in-door climate certification is applied, if such is available for the material type in question [1]	☐	☐
6. There is a minimum air exchange rate of 30 m^3/h per person. The mechanical air exchange rate is at least 0.4/h and it is possible to have 0.6/h extra air exchange rate by manual opening of windows [2]	☐	☐
7. Balanced ventilation, exhaust and inlet air [2]	☐	☐
8. Moisture controlled ventilation [1]	☐	☐
9. Individually controlled ventilation [1]	☐	☐

Building owner's suggestions for other measures within " Indoor air climate":
____

C) Materials and constructions

	PHASE 1	PHASE 2
1. Water installations without PVC is applied [1]	☐	☐
2. Cable work and related installations are without PVC [1]	☐	☐
3. Only building components totally free of PVC are applied [1]	☐	☐
4. Pressure-creosoted wood or similar is not applied [5)] [1]	☐	☐
5. Materials with environmental certification are applied (please specify) [1]	☐	☐
6. Foam materials using CFC and HCFC is totally avoided [1]	☐	☐
7. Gravel replacement in the form of crushes concrete is applied [1]	☐	☐
8. As flooring materials are only applied wood, natural stone or ceramic tiles [1]	☐	☐
9. Insulation materials of recycled organic origin is	☐	☐

applied (for example flax and paper granules) [1]

10. Surfaces are treated with materials that are indoor-climate certified [1]	☐	☐
11. Low “not renewable” energy consumption materials, 200 MJ/m² or less [3]	☐	☐
12. Use of bricks in interior walls [2]	☐	☐
13. Use of polyolefin floors [2]	☐	☐
14. Natural materials in walls [1]	☐	☐
15. Natural materials in flooring [1]	☐	☐
16. Natural materials in roofs [1]	☐	☐
17. Natural materials in ceilings [1]	☐	☐
18. Recycled materials in insulation [1]	☐	☐
19. Recycled bricks are used [1]	☐	☐
20. Recycled tiles are used [1]	☐	☐
21. Special care so constructions are protected against the local weather conditions, e.g. using extended eaves [2]	☐	☐
22. Use of flat roofs are avoided in rainy climates [2]	☐	☐
23. Documented lifetime optimised facades [2]	☐	☐
24. Documented lifetime optimised roofs [2]	☐	☐
25. Documented use of glass and windows to obtain a maximum utilisation of daylight [1]	☐	☐
26. Documented use of glass and windows so overheating in the summer is avoided (less than 26°C in a Danish climate) [1]	☐	☐
27. Documented use of glass and windows in a way so the yearly heat loss including solar gain is less than for the insulated walls [1]	☐	☐
28. Use of built-in solar shading design [1]	☐	☐
29. The building is designed to utilise natural and cross ventilation in the summer [1]	☐	☐
30. The building is made with a documented level of thermal mass as basis of storage of solar gains [1]	☐	☐
31. A building design is used which avoids the need for air condition/cooling systems [2]	☐	☐
32. Areas with a high amount of “free heat” gains is designed for natural or hybrid ventilation [2]	☐	☐
33. A detailed calculation programme is used as basis of achieving an optimised building design with respect to heat and cooling demand and comfortable temperatures [2]	☐	☐

Building owner’s suggestion to other measures within ”Materials and constructions”
____

D) Waste

	PHASE 1	PHASE 2
1. Space for composting container is included in the garden plot [1]	☐	☐
2. Appropriate containers for fractionated waste disposal is built in both in kitchen and in the out door disposal place [1]	☐	☐
3. Green accounting is applied on the household waste [1]	☐	☐
4. The waste from the construction phase is sorted in as many fractions as the municipality can find an outlet for [1]	☐	☐
5. At each main plot of land space is reserved for ”waste-islands” where the waste can be disposed off in fractions as paper, cardboard, metal, electronic waste etc [1]	☐	☐
6. Life cycle assessment of materials [1]	☐	☐
7. Documentation and maintenance guide concerning materials [2]	☐	☐

Building owner’s suggestion to other measures within ”Waste”
____

E) Energy

	PHASE 1	PHASE 2
1. The building project is being coupled to the local district heating [1]	☐	☐
2. User controlled mechanical ventilation with heat recovery of outlet air is installed. The thermal efficiency rate must be at least 80% and the electrothermal ratio [9)] must be at least 1:8. Power consumption max. 40 W and noise level from the installation must be below 25 dB [5]	☐	☐
3. Individual consumption displays are installed [2]	☐	☐
4. The number of hot water taps are limited and are placed centrally with short and small diameter tubing [2]	☐	☐
5. Main meters are placed at the entrance of each main plot of land, so losses from the distribution system can be monitored [1]	☐	☐
6. It is documented to the municipality that the heating system in the house ensures maximum cooling of district heated water and with the lowest possible return temperature [1]	☐	☐
7. Energy consumption for heating below [6)] 46 kWh/m² is documented [2]	☐	☐

8. Energy consumption for heating below [6)] 40 kWh/m² is documented [2]	☐	☐
9. Energy consumption for heating below [6)] 35 kWh/m² is documented [2]	☐	☐
10. Energy consumption for heating below [6)] 30 kWh/m² is documented [2]	☐	☐
11. Energy consumption for heating below [6)] 25 kWh/m² is documented [2]	☐	☐
12. If a domestic hot-water tank is installed, this should be of the standardised type prepared for solar collectors [1]	☐	☐
13. A solar collector for domestic hot water is installed. Sized for 100% coverage in the summer period [3]	☐	☐
14. The housing design is performed in a way that maximises the contribution of passive solar energy without reducing the comfort in periods with high solar exposure [1]	☐	☐
15. Use solar walls as an alternative to conventional façade solutions – for example for preheating of ventilation air [1]	☐	☐
16. Integrated solar protection is installed where passive solar energy is utilised [1]	☐	☐
17. Both hot- and cold water taps are installed at washing- an dishwashing machines [1]	☐	☐
18. All white goods must be certified as “low-energy” types[7)] A. (As white household electrical appliances goods is understood freezers, refrigerators, kitchen range, washing- and dishwashing machines and tumbler drier [2]	☐	☐
19. Low-energy basic lighting is installed. Supplied with user-activated specific lighting [1]	☐	☐
20. Electricity savings amounting to 10% lower than normal is planned [8)] (Documented) [2]	☐	☐
21. Electricity savings amounting to 20% lower than normal is planned [8)] (Documented) [2]	☐	☐
22. A local, covered clothes drying ground is established [2]	☐	☐
23. Tumbler driers are not installed [1]	☐	☐
24. Tumbler driers of the condensing type is installed [1]	☐	☐
25. Only low-energy bulbs are applied [1]	☐	☐
26. Solar cells as power supply for circulation pump in the solar heating system is installed [2]	☐	☐
27. Solar cells as power supply for the ventilation fans are installed [2]	☐	☐
28. Grid-connected solar cells are installed [3]	☐	☐
29. Movement-activated lighting is installed [1]	☐	☐
30. Low energy lighting is installed in all common	☐	☐

areas [1]		
31. Common covered drying grounds are established at the different block of flats [2]	☐	☐
32. A common laundry is established [1]	☐	☐
33. Low temperature floor heating [1]	☐	☐
34. Energy management system survey [2]	☐	☐
35. Energy optimised windows, U-value of total window below 1.2 W/m²°C [3]	☐	☐
36. Use of condensing boilers [2]	☐	☐
37. Biomass based district heating [2]	☐	☐
38. Heat pumps with COP over 3.0 [2]	☐	☐
39. Local CHP plant [2]	☐	☐
40. Primary energy use which is not coming from renewable energy is less than 120 kWh/m², year [3]	☐	☐
41. Deviation of the longest building facade from south is less than 45° [2]	☐	☐
42. As a mean solar energy irradiation to buildings should not be reduced by more than 20% because of shadows, orientation and topography [2]	☐	☐
43. The relation between building surface A and volume V should be A/V < 0.65 m [2]	☐	☐

Building owner's suggestion to other measures within "Energy"
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F) Building and urban development area. Methods for sustainable development and sustainable urban management

	PHASE 1	PHASE 2
1. A "Use & Maintenance" manual is delivered and/or planned for each housing unit. This describes all the types of building materials and technical devices with information about maintenance and relevant supplier information, etc. [2]	☐	☐
2. The Building owner/contractor can document an environmental management system (not necessarily certified), which ensures a minimal environmental impact in the construction phase [2]	☐	☐
3. Green accounting is performed for each building (monitoring of water-, heat- and power consumption) [2]	☐	☐
4. Use of technical installations are done according to the manual mentioned under item 1 [1]	☐	☐
5. The building is optimised according to a total economic lifecycle costs assessment (assessment	☐	☐

of investments where operation and maintenance costs are taken into consideration). Can e.g. be done by help of the “Optibuild” tool which can be downloaded from www.ecobuilding.dk [2]

6. The design is planned for an easy access to technical installations [1]	☐	☐
7. The building project is placed in the existing terrain [1]	☐	☐
8. Existing vegetation is saved and protected in the construction phase [1]	☐	☐
9. Unheated additions are connected to the main building (porch, garage etc.) [1]	☐	☐
10. Extra protection of façades is instituted by means of extended eaves (minimum 700 mm) [1]	☐	☐
11. All fittings in piping systems are easily accessible (non-destructive inspection) [1]	☐	☐
12. Only few modifications are needed to change the housing unit for disabled/older people [1]	☐	☐
13. Differentiated protection of wood is performed (functional wood-protection), dependent of how it is exposed to the weather [1]	☐	☐
14. Joining methods and construction principles are chosen so reconstruction/additions/reuse will be less problematic [1]	☐	☐
15. Green accounting is performed at each main plot of land (monitoring of water-, heat- and power consumption) [2]	☐	☐
16. Technical installations in house blocks are placed in a noise core 10) [1]	☐	☐
17. A green common area is included in each main plot of land [1]	☐	☐
18. A ”nature playing ground” is included in each main plot of land [1]	☐	☐
19. Energy efficiency of realised building project will be assessed by comparing a monitored energy signature, e.g. by help of an energy management system, with a reference energy signature calculated prior to the realisation phase [2]	☐	☐
20. A quality and performance verification process is started already in connection to the design work. Here performance demands and performance indicators are identified [2]	☐	☐
21. A quality assurance procedure is performed both in connection to design and realisation by help of “specialist” companies (check of design and tender material, inspection procedures and performance tests as part of the building process) [3]	☐	☐
22. Check of cold bridges, airtightness, ventilation design, solar energy systems, heating systems, electrical appliances, water systems and waste handling systems as part of performance check	☐	☐

procedure [4]

23. Optimisation and documentation of energy use, heat and cooling demand (yearly and daily) temperatures and daylighting, by help of a detailed calculation programme like “Rensim” [3] ☐ ☐

Building owner’s suggestion to other measures within ” Urban development area and sustainable urban management”
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Appendix

1) Grey waste water is defined as water from sink and shower.
2) Air tightness is performed after the finishing of the building.
3) Daylight optimisation according to DS 700
4) Intensified noise regulations according to NR-curves (Noise Rating Curves)

5) **If** pressure impregnated wood is applied it must be NTR-marked or impregnated with compounds approved by the Danish Environmental Agency.
6) Energy consumption amounting to e.g. 46 kWh/m^2 means that the consumption must be maximum 46 kWh pr. m^2 floor area per year .
7) On the Danish “Electricity Saving Fund’s” website www.elsparefonden.dk there is information about energy marking of household appliances and price reduction terms for larger scale purchases.

8) It must be documented that electricity savings higher than the normal (4 kwh/m^2) is obtained for the building.

9) The electrothermal ratio for heat recovery systems is the ratio between the electricity consumption and the savings in heat consumption (documented)
10) Noise core is defined as a shaft, which ensures that noise from technical installations is not exceeding the values given in the Danish building regulations.

The statements about water savings originate from the recommendations from ”Københavns Vand” (Copenhagen Water), a publication called ”Miljøorienteret byfornyelse og nybyggeri”, the municipality of Copenhagen, 1999.

ANNEX III

"Green Build" questionnaire concerning environmental initiatives in retrofit and urban renewal projects.

Guidelines for the use of the questionnaire.

The questionnaire can be used for assessment of the environmental conditions and urban environmental initiatives in connections to retrofit and urban renewal.

The answering of the questionnaire is divided up according to the urban renewal 20 point programme and should be answered in two phases showing what the intention is and what actually has been done.

Phase 1 - the building owner intentions before the retrofit urban renewal
Phase 2 - what is actually accomplished.

The questionnaire is filled in by ticking off all the questions. E.g. regarding energy savings on heating. If the dwelling has a energy consumption of 32 kWh/m² all 5 lines should be ticked off.

√ Energy consumption is below 80 kWh/m²
√ Energy consumption is below 70 kWh/m²
√ Energy consumption is below 60 kWh/m²
√ Energy consumption is below 50 kWh/m²
√ Energy consumption is below 40 kWh/m²

"Green Build" questionnaire

		Phase 1	Comments	Phase 2	Comments
1.1	**Building constructions generally**				
1.1.1.	**Roof and roof constructions**				
1.	In connection with change of the roof a decision will be taken on the possibilities for a possible mounting of sun cells or photovoltaic (PV) modules as well as solar thermal collectors. In any case preparations are made for a possible later mounting of PV modules or solar thermal collectors,				

	including labelling / piping to inverters or storage tanks in loft room or cellar [1]				
2.	Extra insulation of attic is carried out from a total economic optimisation and with check systems concerning cold bridges [1]				
1.1.2	**Facade and facade construction**				
1.	In connection with renovation of the facades it is checked whether it will be practical to place the PV modules on the facade. In any case preparations are made for a possible later mounting of PV modules including labelling to cellar [1]				
2.	An improved insulation of facades are carried out from a total economic optimisation and with a check system for cold bridges [1]				
		Phase 1	Comments	Phase 2	Comments
1.1.3	**Windows and entrance doors**				
1	Daylight optimisation in connection with choice of windows [1]				
2.	The dwelling is optimises regarding utilisation of passive solar heat, with an account of how possible overheating problems, if any, have been solved [2]				
3.	When changing windows. Energy optimised windows are installed [2]				
4.	U-value for window including frame / window sill below 1,2 W/m²°C, check system for cold bridges [2]				
5.	Windows are optimised regarding inflow of light and / or sunshading, documented				

	[1]				
6.	During renovation of windows existing windows are kept, but based on an energy economic optimisation e.g. by using removable airtight windows [2]				

		Phase 1	Comments	Phase 2	Comments
1.1.4	**Foundation and cellar construction**				
1.	Improved insulation of cellar and ceiling, check system for cold bridges [1]				
1.1.5	**Materials in general**				
1.	Only building components and installations totally free of PVC are applied [2]				
2.	Pressure-creosote wood is not applied [1]				
3.	Where possible only materials with environmental certification are applied (documented) [2]				
4.	Foam materials using CFC and HCFC are totally avoided [1]				
5.	Gravel replacement in form of crushed concrete is applied [1]				
6.	Alternative insulation using “green” materials or materials of recycled organic origin (e.g. flax and paper granulate [1]				
7.	Materials which require depositing are avoided[1]				

		Phase 1	Comments	Phase 2	Comments
8.	Mainly use of materials which are:				

	1 : recyclable 2 : renewable 3 : "green" materials (documented) [1]				
9.	Documentation (e.g. BEAT-calculation) of low "not renewable" energy consumption for materials, divided up in : Over 3000 MJ/m² Over 2000 MJ/m² Under 2000 MJ/m² [1]				
10	Use of indoor materials with documented indoor climate quality (Danish Indoor climate certificate) if such materials are in existence within the range of the required type of material [1]				
11.	Differentiated protection of woodwork through choice of wood, design and construction including surface treatment depending on weather influence [1]				
12.	Documented lifetime optimised facade solutions are used as regards energy consumption, materials, level of maintenance or similar [2]				
13.	Documented lifetime optimised roof solutions are used e.g. with reference to lifetime of tile roofs and underroofs [2]				
14.	Documented optimised use of glass and windows to obtain a maximum utilisation of daylight [1]				

		Phase 1	Comments	Phase 2	Comments
15.	Documented optimised use of glass and windows so overheating in summer is avoided (less than 26°C) [1]				
16.	Description of environmental assessment in connection to choice of materials [1]				

17.	Choice of materials from an estimate of maximum lifetime and minimum operation and maintenance (life cycle optimisation) [2]				
18.	The building scheme is designed so as to use natural cross ventilation during summer [1]				
19.	A detailed calculation programme is used, e.g. BSIM, TRNSYS or Energy 10, as basis for achieving an optimised building design with respect to heating and cooling demands and comfortable temperatures [2]				
1.2	**Building constructions – indoor**				
1.2.1	Floor slab, ceiling and floor				
1.	As flooring materials are only applied wood, natural stone or ceramic tiles [1]				

		Phase 1	Comments	Phase 2	Comments
1.3	**Building installations**				
1.3.1	Heating installations				
1.	The building project will be connected with the local district heating [2]				
2.	Use of condensing furnace [1]				
3.	Use of individual energy / supply meters [1]				
4.	Heating with low temperature operation 60/40°C [1]				
5.	Documented low distribution				

	losses for heating (max. 15%) [1]				
6.	Optimised heating system as compared to saved level of power [1]				
7.	Individual consumption displays are installed [2]				
8.	Number of draw-off points are limited and the points are placed centrally with short pipes and a small diameter [2]				
9.	Main supply meter for heating will be installed, registering losses from the distribution grid [1]				

		Phase 1	Comments	Phase 2	Comments
10.	The municipality has received documentation to the effect that the heating system in the house ensures maximum cooling of district heated water and with the lowest possible return temperature [1]				
11.	Energy consumption for heating 2) is below 80 kWh/m² [1]				
12.	Energy consumption for heating 2) is below 70 kWh/m² [1]				
13.	Energy consumption for heating 2) is below 60 kWh/m² [2]				
14.	Energy consumption for heating 2) is below 50 kWh/m² [2]				
15.	Energy consumption for heating 2) is below 40 kWh/m² [2]				
16.	A solar collector for domestic hot water is installed. Sized				

	for 100% coverage in the summer period [3]				
17.	The housing design is performed so as to maximise the contribution of passive solar energy [1]				
18.	Use of solar walls as an alternative to conventional facade solutions – e.g. for preheating of ventilation air [1]				
19.	Integrated outdoor solar protection is installed where passive solar energy is intended utilised [1]				
20.	Optimisation of total heat supply solution as regards reduction of distribution losses for heating as well as hot water (documented) [1]				
		Phase 1	Comments	Phase 2	Comments
21.	Use of monitoring equipment and energy characteristics for optimum heat consumption [2]				
22.	Demand controlled balanced mechanical ventilation with heat recovery is installed where the exhaust air is used for heating inlet air [2]				
23.	The heat recovery efficiency for ventilation with heat recovery ought to be min. 80% and the electro thermal condition min. 1:8 [2]				
24.	No use of electricity for heating purposes [1]				
25.	The average energy consumption for heating and hot water will be reduced with minimum 20% as compared to consumption before the urban renewal [2]				
1.3.2	**Water and plumbing**				
1.	Water saving toilets with				

	differentiated flush are installed (3/6 litres) [1]				
2.	Rain water collection for garden irrigation is installed [1]				
3.	Water saving taps are installed. Wash basin max. 6 l/min. Kitchen sink max. 12 l/min. and shower max. 12 l/min. [1]				
4.	A main water metering device is installed in each block, for use in green accounting for all blocks [1]				

		Phase 1	Comments	Phase 2	Comments
5.	Measures to minimise the amount of rain water collected by the sewage system are carried out (permeable pavements, rainwater ponds, fascines etc.) [1]				
6.	Rainwater collection for use in washing machines is installed [2]				
7.	Rainwater collection for use in toilet flushing is installed [3]				
8.	Washing- and dishwashing machines with minimised water consumption are installed [1]				
9.	Thermostat mixer tap for showers of a type which can be serviced without opening the installation [1]				
10.	“Grey”waste water is utilised 1) [4]				
11.	Use of water- and drainage installations without PVC [1]				
12.	Use of individual water meters, with consumption display, for hot and cold water [1]				
13.	Domestic cold water pipes are installed in order not to be warmed-up by the surroundings [1]				

		Phase 1	Comments	Phase 2	Comments
1.3.3	**Electric installations**				
1.	Use of electric installations without PVC [1]				
2.	Installation of individual consumption display for electricity consumption [1]				
3	Hot- and cold water taps are installed in connection with washing- and dishwashing machines [1]				
4.	All white goods must be certified as “low energy” 7) type A or be prepared for that. (White household electrical appliance goods are freezers, refrigerators, stoves, washing machine, tumble dryers and dishwashing machines [2]				
5.	Low basic lighting is installed outdoor. Supplemented with user activated stronger specific lighting [1]				
6.	Electricity savings amounting to 10% compared with normal 8) is planned (documented) [2]				
7.	Electricity savings amounting to 20% compared with normal 8) is planned (documented) [2]				
8.	Tumbler dryers are not installed [1]				
9.	Tumbler dryers of the condensing type (if installed in cellar only after thorough evaluation) [1]				

		Phase 1	Comments	Phase 2	Comments
10.	Use of low energy bulbs only [1]				
11.	Installation of solar cells as power supply for the circulation pump in the solar heating system [2]				
12.	Installation of solar cells as power supply for the ventilation fans [2]				
13.	Installation of grid connected solar cells [2]				
14.	Installation of movement activated lighting, where this comply with the demand pattern [1]				
15.	Installation of low energy lighting in all common areas indoor as well as outdoor [1]				
16.	Establishment of alternative space for clothes drying rack of the outdoor area of the single dwelling, or common outdoor drying spaces, or drying spaces in attics or in basements. In that case good natural ventilation is required[2]				
17.	Use of common laundry with low energy washing machines [1]				
18.	Power consumption for ventilation per dwelling below 40 W for installations with heat recovery and 25 W for installations with exhaust ventilation [2]				
		Phase 1	Comments	Phase 2	Comments
19.	Power consumption for ventilation with heat recovery below 0,2 $W/m^3/h$ (at 125 m^3 it is equal to 25 W) [2]				
20.	Wiring prepared for				

	connection of energy efficient fixtures and energy efficient light sources [1]				
21.	Within a possible gas net area the gas installations should be utilised if possible [1]				
22.	Entrance lighting is controlled from the dwelling [1]				
23.	If darkness is acceptable in periods lighting can be activated by user-activated detectors [1]				
1.3.4	**Indoor air climate and ventilation**				
1.	Airtightness measurement 3) of the building in order to document a natural air change via constructions, below 0,1/h [2]				
2.	Noise from installations in living room is below 25 dB [2]				
3.	Easy access for check-up of installations [1]				
4.	Inspection possibilities available for all pipe joints [1]				
5.	Installation of user controlled balanced mechanical ventilation with heat recovery, on demand, where exhaust air is used for heating of inlet air [2]				
		Phase 1	Comments	Phase 2	Comments
6.	Installations in a building of flats are placed in a 5) “core of noise” [1]				
7.	The mechanical air exchange rate is at least 0,4/h and minimum 30 m³/h per person [2]				

8.	Use of balanced ventilation, exhaust of used air and inlet of fresh air [2]				
9.	Use of humidity controlled ventilation [1]				
10.	Possibility of individually user controlled ventilation [1]				
1.3.5	**Waste**				
1.	Space for composting container is included in the garden plot [1]				
2.	Appropriate containers for fractionated waste disposal are built in kitchens and in the outdoor disposal places [1]				
3.	Green accounting is applied for the household waste [1]				
4.	The waste from the construction phase is sorted in as many fractions as the municipality can find an outlet for [1]				
5.	At each main plot of land space is reserved for "waste islands" where the waste can be disposed of in fractions like paper, cardboard, metal, electronic, waste etc. [1]				
		Phase 1	Comments	Phase 2	Comments
6.	Life cycle assessment of building materials [1]				
2.	**Technical consultancy**				
1,	A "Use and Maintenance" manual is delivered and/or planned for each housing unit for the builder. This describes all the types of building materials and technical devices with information on maintenance, relevant supplier information and technical installations etc. [2]				

2.	A short account of the synthesis of architectural quality and environmental quality of the total project [1]				
3.	Preparation of an environmental account for each project [1]				
4.	Active working concerning the promotion of product development in the urban environmental area e.g. with “green foodstuffs” [1]				
5.	Demolition with recycling of materials and with a minimum of pollution [1]				
6.	Efficient shielding of worth preserving vegetation is established [1]				

		Phase 1	Comments	Phase 2	Comments
3.	**Building owner, administration and outdoor areas**				
1.	The building owner/contractor can document an environmental management system (not necessarily certified) which ensures a minimal environmental impact in the construction phase [2]				
2.	Documentation of waste processing solution in the construction phase [1]				
3.	Green accounting is applied for each dwelling (registration of water, heat and power consumption) [2]				
4.	Operation of installations according to maintenance manual [1]				

5.	The building is optimised on a total economic basis (estimation of investments as compared to operation and maintenance [2]				
6.	Using few modifications the dwelling can be altered to a senior / handicap dwelling [1]				
7.	Use of construction principles and choice of materials to facilitate retrofit and recycling of building materials [1]				

		Phase 1	Comments	Phase 2	Comments
8.	A green common area is included in each main plot of land [1]				
9.	A “nature playing ground” is included in each main plot of land [1]				
10.	Realisation of a life cycle estimation of the total building, from e.g. the BEAT-calculation [2]				
11.	Realisation of environmental planning / designing e.g. based on BPS121 and/or ABC planner [2]				
12.	When possible existing vegetation is kept, and favourable conditions of growth for the plantation are secured. Plantation is chosen in order to secure experience of nature through flowering, the berry-season and leaf fall [1]				
13.	Green common areas are prepared with max consideration for environmental maintenance thus avoiding use of pesticides in installations and				

	operation of these [2]				
14.	Building ground areas are minimised and finished with grubbing and milling [1]				
15.	Wetlands are sought to be established on common areas [1]				

		Phase 1	Comments	Phase 2	Comments
16.	Plantation plans are devised to secure shelter, creation of space and use of facade plantation, e.g. espalier where extensive plantation is not possible [1]				
4.	**Financing**				
1.	If possible use of financing principles which further a sustainable development e.g. calculated points over a certain level can secure a more beneficial financing e.g. with low interest and a long term [4]				
1.1	**Structural engineering generally**				
1.1.1	Roof and roof construction				
1.1.2	Facade and facade construction				
1.1.3	Windows and entrance doors				
1.1.4	Foundation and cellar constructions				
1.1.5	Materials generally				
1.2	**Building constructions – internal**				
1.2.1	Floor slab, ceiling and floor constructions				

		Phase 1	Comments	Phase 2	Comments
1.3	**Building installations**				
1.3.1	Heat installations				
1.3.2	Water and plumbing				
1.3.3	Electric installations				
1.3.4	Indoor air climate and ventilation				
1.3.5	Waste				
2.	**Technical consultancy**	0		0	
3.	**Building owner, administration and outdoor areas**	0		0	
4.	**Financing**	0		0	
	Total				

Good	=	130 - 188 points
OK	=	53 – 129 points
Improvement advisable	=	0 - 52 points

Notes :

1. If pressure impregnated wood is applied it must be NTR-marked or impregnated with compounds approved by the Danish Environmental Agency
2. Energy consumption for heating e.g. 46 kWh/m², year means that max. 46 kWh per m² floor area per year is used for heating /tests for airtightness
3. Blowerdoor tests are performed after the finishing of the building to show airtightness of the dwelling
4. The electrothermal ratio for heat recovery is the ratio between the yearly electricity consumption for ventilation systems and the yearly savings in heat consumption (documented)
5. Noise core is defined as a shaft which ensures that noise from technical installations is not exceeding the values in dB given in the Danish building regulations.

ANNEX IV

"CO_2-neutral" prefabricated roof top apartment

In connection to the EU-DEMOHOUSE project a concept for an energy efficient, so called "CO_2-neutral" roof top apartment has been developed. The concept is aimed to be realised in connection to retrofit of large housing areas with concrete housing blocks in Copenhagen, including the Gyldenrisparken demonstration project.

The idea has been to create an economically and environmentally energy efficient sustainable penthouse solution, by introducing prefabricated building elements for easy and safe establishing of new dwellings on existing buildings.

The concept

The general concept has been developed through a co-operation between actors specialised in different fields like architecture, engineering, energy efficiency, product development, prefabrication of building parts and a local community administration for the general city development (Nielsen & Rubow architects, Cenergia, the Velux Group and Urban Renewal Copenhagen).

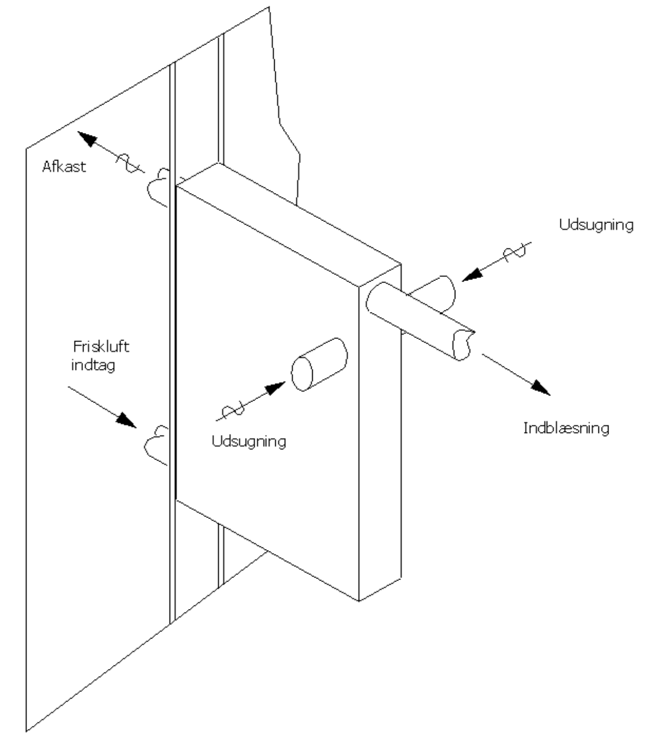
The technical result is a combination of a range of innovative, both low and high, technical solutions like: improved insulation and low energy windows, the use of solar energy through solar heating and photovoltaic, heat recovery ventilation and hybrid ventilation.

The aspect of prefabrication is seen to support the demands for the building of the future as it brings the opportunity to integrate the individual parts of the building (floor, walls, roof) in a cost effective and high quality way. This will help avoiding the thermal bridges and enhance the air tightness. Furthermore the prefabrication method will simplify the process of transportation and be economic at the same time allowing extra costs for energy efficiency measures.

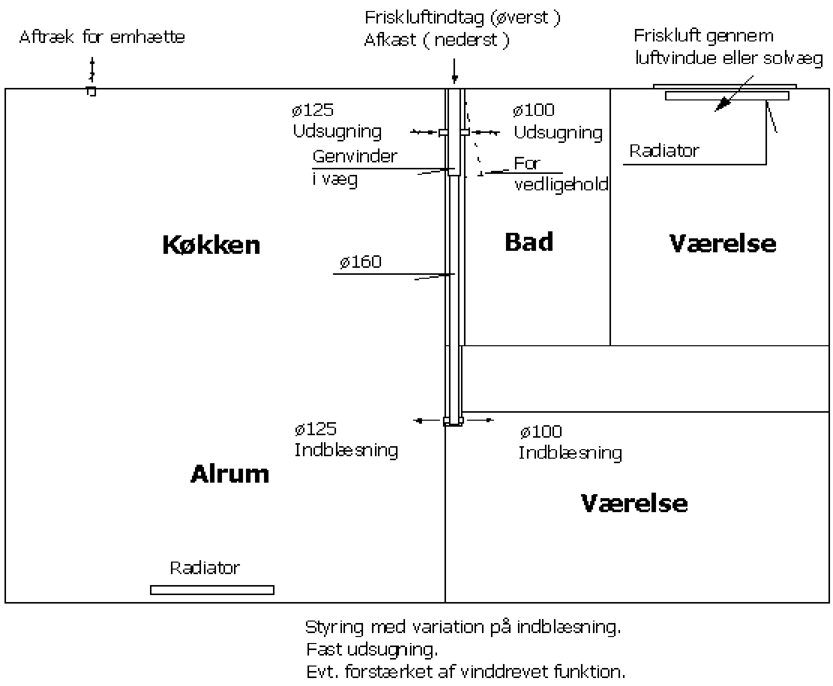
The prototype rooftop apartment was manufactured by the Danish building company Jytas and has been exhibited in Ørestaden in Copenhagen from the end of August 2005 (see also: www.soltag.net). The principles for the penthouse concept were taken from a small test house which was build in 2003, showing fine results for airtight buildings and without thermal bridges as basis of CO_2 neutral building.

Fig. 1: CO_2 neutral rooftop apartment. Exhibition in Ørestaden, Copenhagen.

- Compact only 20 cm thick heat recovery ventilation unit placed in a partition wall. (EcoVent)
- Preheating of ventilation air in metallic roof, air solar collector (Rannilla) with 13 m² PV modules covering ventilation and lighting demand from solar energy
- Wooden air tight housing construction with paper granulate-insulation and no cold bridges (U-value: 0.15 – 0.18 W/m²°C)
- Low-energy windows. Velux / Velfac
- A ”house-without-heating system” concept



The only 20 cm thick air heating unit with heat recovery ventilatiom from the danish company EcoVent is easy to integrate in e.g. a partition wall.

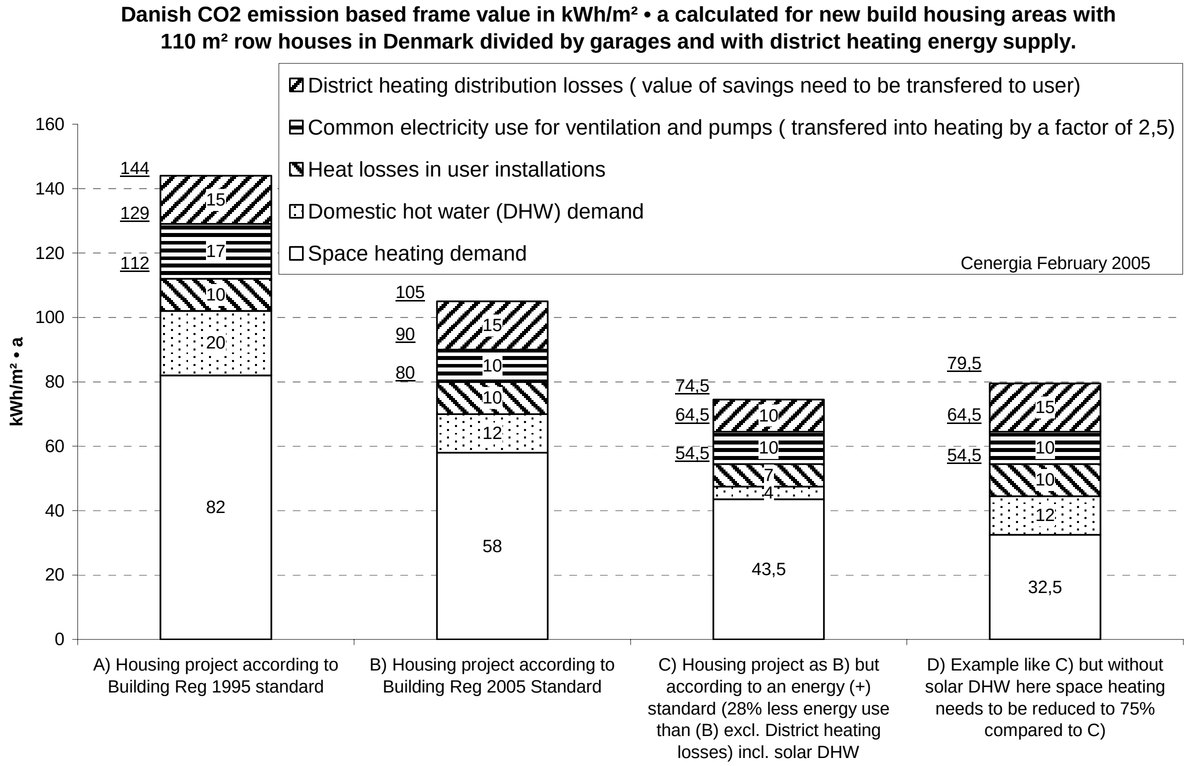


ANNEX V

New Energy Demand in the Danish Building Regulations

In the following is shown a presentation of how the new energy demands in the Danish Building Regulations will look like for a new housing area (B), compared to the Building Regulations 1995 (A), and to a low energy standard 2, (C) and (D) which is 25% better than the minimum standard.

District heating network losses are also indicated, but are not part of the calculated frame value which, as something new, includes electricity use for ventilation and pumps multiplied by a factor of 2.5, so you can add it together with the heating based energy consumption as a total CO_2 emission based frame value.



This means that you should compare (A) = 129 kWh/m² a with (B) = 90 kWh/m² a and (C), (D) = 64.5 kWh/m² a. Where (C) is utilising local solar DHW systems with electricity back-up and summer stop of district heating in three months.

The calculations have shown that if you utilise a new type of low cost heat recovery ventilation with low electricity use, this is the cheapest way of meeting the new minimum energy demands, while perhaps a little surprising use of very small solar DHW systems (with 2-3 m² solar collectors) are an economic solution as part of an energy saving package to meet the demands of the new low energy standard 2.

The used technical solutions for (B), (C) and (D) are as follows including some information on the existing standard (A):

A: The energy use is normally 20-50 % higher due to lack of control of energy quality.

Estimated extra costs compared to (A) to ensure energy quality: ½ % of building costs is 40 DKK/m² = 6 Euro/m².

This can be realised with a very good economy because monitored energy use will be very near to calculated energy use.

B:	Main energy saving features: - Heat recovery ventilation and air tightness - Extra domestic hot water savings (estimated extra costs compared to A: 110 DKK/m² = 15 Euro/m²
C:	Main energy saving features: As (B) including: - Solar DHW heating systems in combination with solar prepared DHW tanks - Extra avoidance of cold bridges - Improved insulation in attic (estimated extra costs compared to ((A B): 110 DKK/m² = 15 Euro/m²)
D:	Main energy saving features: As (B) including: - Improved windows with 3 layer energy glass - Extra avoidance of cold bridges - Improved insulation in general (estimated extra costs compared to ((B) = 200 DKK/m² = 27 Euro/m²)

Calculated yearly energy and operation cost savings:

B:
[(112 – 80) kWh/m² a = 32 kWh/m² a x 0,355 DKK/kWh] = 11,4 + 9,5 = 20,9 DKK/m² a
+ [(17-10) kWh/m² a x 1,36 DKK/kWh] = 2,82 Euro/m² a

C, D:
(112 – 54,5) kWh/m² a = 57,5 kWh/m² a x 0,355 DKK/kWh = 20,4 + 9,5 = 29,0 DKK/m² a
+ [(17-10) kWh/m² a x 1,36 DKK/kWh] = 4,0 Euro/m² a

This means the payback time to meet the new minimum energy demands (B) are:
15 Euro/2,82 Euro = 5,3 years.

At the same time the payback time to realise an energy (+) standard with a here calculated extra 28% energy saving is:

C: (15 + 15) Euro/4,0 Euro per year = 7.5 years.
D: (15 + 27) Euro/4,0 Euro per year = 10.5 years.

Besides it could be argued that an "energy quality" standard with extra preparation and control costs by an independent energy expert assistance to reach the new energy minimum demands (B) should be a part of the economy calculation.

These costs are estimated to be ½ % of the total building costs. This is only 5 % compared to the normal design fee costs. In actual costs it is around 6,0 Euro/m².
However, it can be less at larger building projects, and in fact it not only ensures the above shown savings, but also improves the general energy quality standard compared to today with extra energy savings.

If you can avoid a 30 kWh/m². a extra energy use for heating, e.g. the value of this is approximately 2,6 Euro/m². a. With an extra investment of ½ % of total building costs, to obtain this the payback time will be 2-3 years for the investment.
This is so positive that you could even suggest to allocate another ½ % of the building costs as a bonus to the contractor if they meet the energy saving level within e.g. a 10% difference.

Based on the here mentioned there is no doubt about the need to realise "Intelligent Energy (+) and Energy Quality Implementation" in future building projects. It is just a question of how you can organise it in practice, e.g. related to local policies in the EU-member countries.

ANNEX VI

Note on energy efficiency of low energy housing demonstration projects realised at BO-01 in Malmö

In the Western Harbour of Malmö in Sweden a building exhibition BO-01 which was also supported by the EU was realised in 2001.
Here it was decided that the average energy use should not exceed 105 kWh/m². a covering both energy use for heating, domestic hot water, (DHW) and common electricity use.

The result of a monitoring campaign (see ref. (1)), for 10 different multifamily housing estates, has been that especially the heating consumption was much higher than expected according to calculations.
The overall result was 186 kWh/m²for housing areas without heat recovery on ventilation and 127 kWh/m². a for housing areas with heat recovery ventilation.

Most housing projects reported 40-60 % higher energy use than reported by the developers.

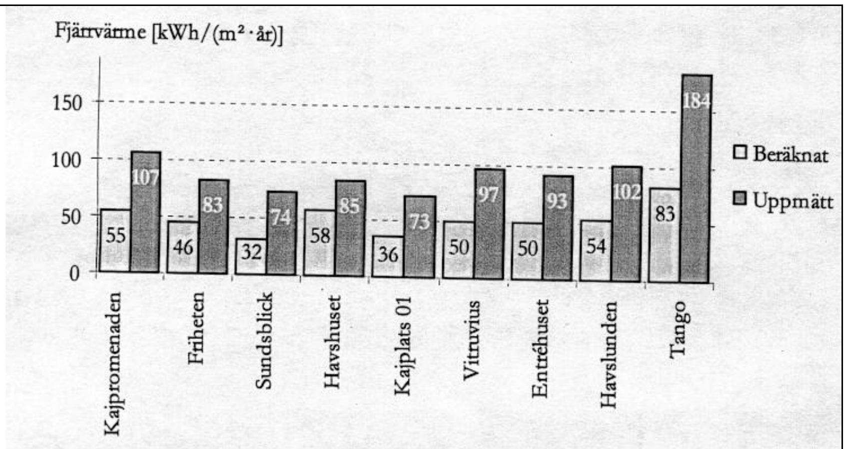
The energy supply company, Sydkraft, counted on an energy use for heating of 70 kWh/m². a and electricity 35 kWh/m²a.

Below are shown results concerning district heating and common electricity energy use for the 10 different housing estates.

District heating kWh/m², year

Light column: Calculated

Dark column: Monitored



DHW use kWh/m², year

Light column: Calculated

Dark column: Monitored

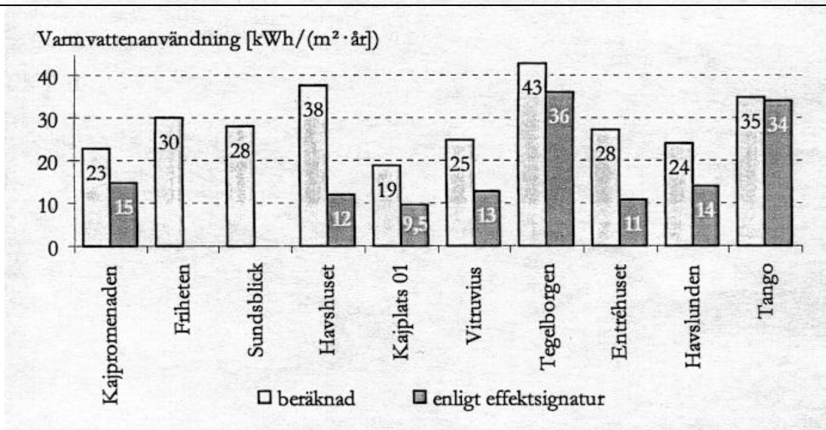
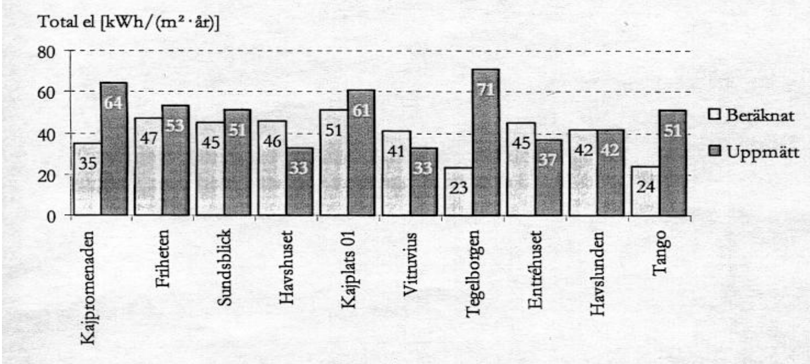


Fig. 1: Calculated and monitored district heating use for the 10 different housing schemes at BO-01. Also DHW energy use is shown.

Total electricity kWh/m², year

Light column: Calculated

Dark column: Monitored



Electricity kWh/m², year

Light column: Common electricity use

Dark column: Individual electricity use

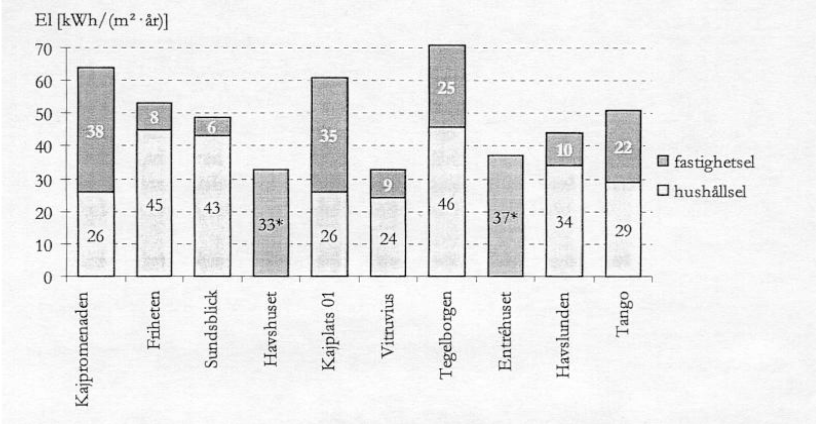


Fig. 2: Calculated and monitored total electricity use for the 10 different housing schemes at BO-01, and divided in common electricity use and individual.

Ref. (1):
Annika Nilsson, report TVBH-3045 from Lunds Technical University, Dept. of Building Physics 2003.
Energy use in new build multi family housing schemes in the Western Harbour, the BO-01 housing exhibition area of Malmö.

ANNEX VII
Proposed minimum demands in connection to Green Diploma for new build and retrofit of housing projects.

In the following is described a model which can be used for new build as well as for retrofitting of housing projects.
Here retrofitting can typically be divided into extensive retrofit projects or urban renewal where one existing building can be converted in almost all areas as opposed to limited retrofit projects where work is carried out by implementing improvements of single building areas at a time, e.g. replacement of windows.

For the last mentioned area single initiatives ought to be implemented as recommended in point 3, just as elements of energy quality control, point 2 mentioned below, can be implemented.

1.		**Use of Energy Plus standard.**
	-	This is an energy standard which is a level higher than the usual standard. E.g. with the new energy demands for new build in Denmark this means that the low energy class 2 can be chosen which is 25% better than the new energy demands which comes into force on January 2006.
2.		**Use of a energy quality control**
	-	In order to secure a high quality of implemented energy savings an energy quality check has to be implemented using an independent energy specialist organisation. This should include e.g. blowerdoor test concerning airtightness, thermo photography concerning cold bridges and description of energy characteristics for the building (measuring the energy consumption in W/m² as a function of the outdoor temperature). These methods can also be used with advantage before retrofit projects are started in order to secure the correct foundation for an optimal effort.
	-	After one year operation a green accounting should be calculated per m², per person which includes : 1 : Heating, 2 : hot water, 3 : heat consumption, 4 : electricity use for ventilation, pumps, outdoor lighting, elevators and other joint facilities and 5 : registration of losses in connection to heat and energy supply.
	-	Registration of indicators of indoor air climate including noise, temperature and humidity.
3.		**Use of Green Catalogue forms for securing energy quality for single initiatives a level higher than the usual standard. (See www.greencatalogue.com).**
	-	For a number of chosen areas such as, insulation, windows, ventilation with heat recovery etc., Green Catalogue forms on “Best Available Technologies”, BAT’s, or best possible technologies should be used, in order to choose a level of quality a level higher, that the usual standard, per 1st January 2006.

4.		**Use of Green Catalogue check list regarding energy and environmental quality including calculation of energy and environmental points. (See www.greencatalogue.com.)**

	-	In the preliminary project phase : Check lists / questionnaire are filled in concerning a number of qualities within the following areas : Refuse, water, indoor air climate, building materials, energy and building area and building sproject. Within each area the level of points which can be obtained is calculated.
5.		**Additional conditions.**
	-	Avoidance of toxic materials by using a black list
	-	Bio factor for buildings is calculated
	-	Total economy for building project should be documented comparing additional investments with savings
	-	Building should be prepared for use of solar energy e.g. roof solutions with roofs facing south on which it is easy to install PV-modules without risk of shadowing.

ANNEX VIII
Green Quality Building Principle

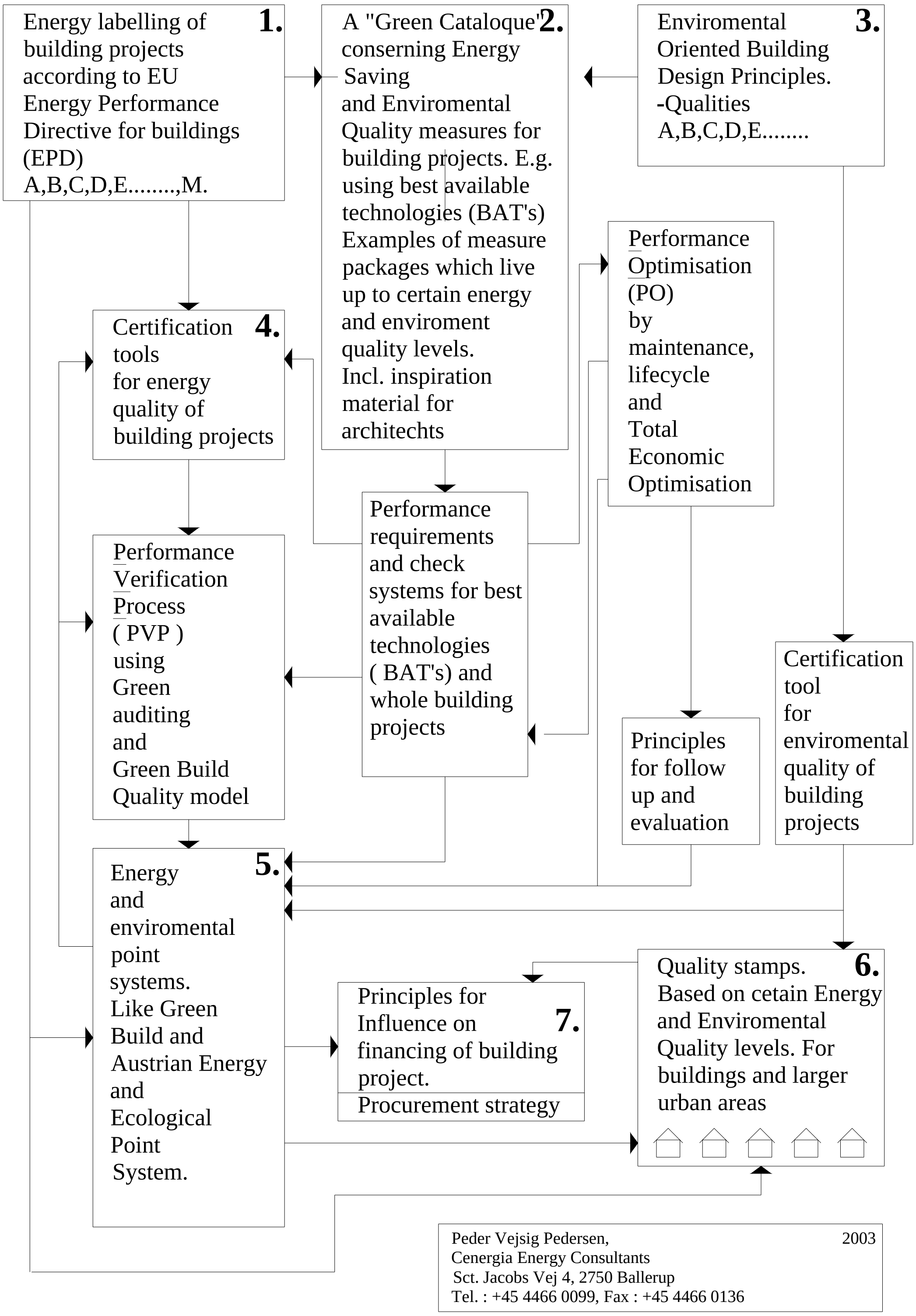


Illustration of the Green Quality Building principle, which is combining energy and environmental labelling with performance verification and promotion schemes.