ENERGY REFURBISHMENT OF FÆSTNINGENS MATERIALGÅRD

PHOTO OF BUILDINGS AND COURTYARD

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INTRODUCTION

This report is produced for SBI.

The basis for this report is the project Fæstningens Materialgaard, owned by Realea and carried out by Realea Byg. The project includes the restoration of four different buildings in the complex Fæstningens Materialgaard. An energy analysis of the buildings was carried out as part of the project. The analysis has indicated possible solutions for how the CO2 level can be reduced whilst at the same time ensuring an internal climate which matches the applicable guidelines and directions from the Danish Working Environment Authority. These solutions have been developed in an interdisciplinary workgroup consisting of the building owners, the authorities (Heritage Agency), the architect and engineers.
This report gathers the overall conclusions from this interdisciplinary work, and will describe the cross-discipline challenges, and potential solutions, which are encountered in connection with the restoration of listed buildings.

The aim of the report is therefore to inspire other building owners who face the restoration of a listed building (with the same application) and who desire to focus on an energy-efficient solution and the internal working environment climate conditions seen as a whole. This is relevant for more than 1.000 other listed buildings in Denmark which are used for office purposes.

CONTENTS

BUILDING COMPLEX

FÆSTNINGENS MATERIALGÅRD

Frederiksholm originated as part of the expansion of Copenhagen’s defences. After the construction of Vester Vold the area within that boundary immediately began to fill up.

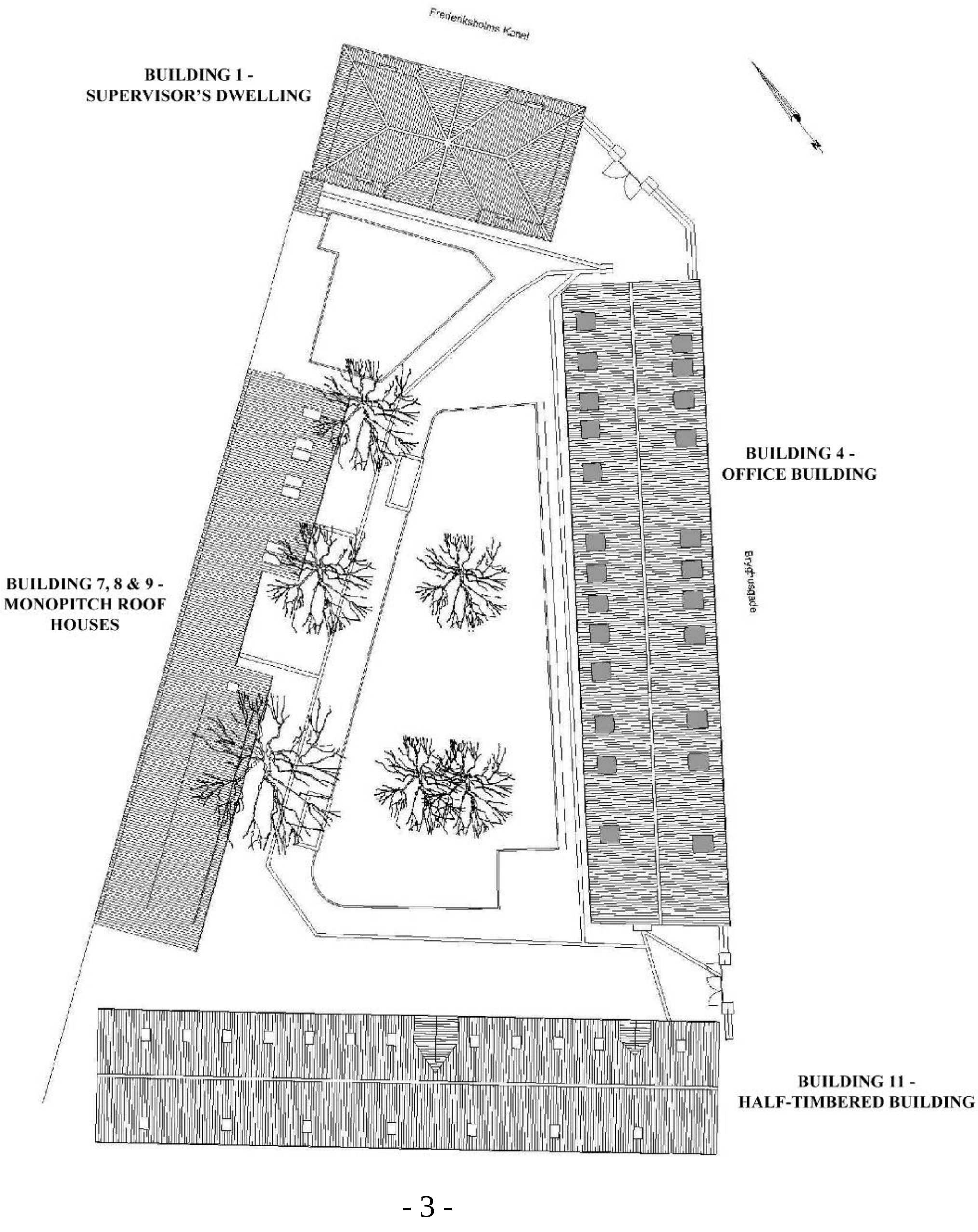
In 1681 Frederiksholms Canal was dug, and a new materials storage yard (Fæstningens Materialgård) was built to replace the old royal materials yard. The complex began in 1740 with a new, very distinguished, brick residence for the supervisor.

The architect for the building is not known for sure, but is assumed to have been the national building master J.C.Krieger.

The buildings form a single building complex, with detached building volumes, surrounded on three sides by Bryghusgade, Frederiksholms Canal and Vester Voldgade.

In essence the complex consists of brick buildings with red tile roofs, yellow lime washed facades, green painted doors and gates and white painted windows. Only the original warehouse building towards Vester Voldgade is built with a half-timbered construction.

SITE PLAN



LISTED STATUS.

The buildings and courtyard area have listed status (i.e. they are listed as having protected status). The listing is based on the Danish law on protecting buildings and the conservation of buildings and the built environment, according to the legislative decree no. 1088. The aim of the law is to protect the country's older buildings which are of architectural, cultural or environmental value, including buildings that highlight residential, working and manufacturing conditions as well as other important features of the development of society.

As the owner of a listed building one is required to responsibly maintain the building. All building work which goes beyond normal maintenance requires permission from the Heritage Agency.

When carrying out building work in a listed building, the same techniques and materials which were used to build the original building should be used. Building materials and techniques are characteristic of both the period and the region, both of which are an integral part of the culture of the building, and they are therefore a part of its heritage value. This is especially applicable to proven materials and techniques which were developed over a long time, through experience. If experimental materials or techniques are to be used in a listed building it should be ensured that they are implemented in such a way that they can be removed again.

BUILDING 1 – SUPERVISOR'S DWELLING

BBR:

Vester Kvarter,
København
246 – Building 1

AREA:

411 m^2

HISTORY

The building which is still standing towards Frederiksholm Canal was built in 1740 as a residence for the Warehouse Supervisor.

The building is nine bays long, with a three-bay gable dormer to both the road and the courtyard, and consists of one storey over a basement. The roof contains a high mansard storey. Two chimney pots adorn the red tile roof on the yellow washed, stone building.

The supervisor's dwelling has historically always been the 'signature' building in the complex. The placement and architecture emphasise the special significance of the building in Fæstningens Materialgård. The high plinth elevates the building from street level and creates a distinction between it and the other buildings, where the original warehouse functions necessitated level access.

The main stairs in the building have been moved twice, which has had an influence on the layout in the rest of the building and the placement of the main doors in the facade. In 1833 the stairs were moved for the last time and the current room disposition is preserved pretty much intact from that time.

Originally the middle room stretched over four bays, differing from the façade which was divided into three lots of three bays. The middle room had a status as a hall, and was the most important room in the 'grand' ground floor. On the plans from 1833 the walls between the rooms are moved so that there are now two main rooms, each over three bays.
The layout therefore went from containing one primary hall, with associated enclosures, smaller chambers and kitchen, to, after the partition walls were moved, containing more equal rooms.

Architrave from around 1740 and 1765-70 can be found in certain places on the ground floor and many places on the first floor. The original windows with cross-post are mostly preserved.

Original spandrel panels can be found on the ground floor, while on the outer walls reveal lining with built-in shutters has been added. The joinery work in many rooms contains elements from many different periods/styles, although they combine to create nice wholes.

The building has most recently been used for several office type functions. This has resulted in that the building contains room divisions, technical solutions etc. which do not respect the values of the building.

FUNDAMENTAL HERITAGE VALUES

- The representative character of the building and the placement of the building in the hierarchy of the complex
- Hierarchy between the storeys
- Rooms and interiors containing a composition of historical styles
- Joinery detailing

The approach towards how each individual building is restored (repaired, rebuilt, converted) and how new elements are added is based on the antiquarian and architectural values which are associated with the characteristics or original type of that building.

The Supervisor's Dwelling is characterised as the 'grandest' building in the complex, and there is a desire to unearth and enhance the fine, richly furnished interiors.

STRUCTURE OF THE BUILDING

FOUNDATIONS:

The building has masonry foundations on oak piles.

OUTER WALLS:

The outer walls are solid brick with a thickness (incl. rendering) of 83 cm in the basement, 71 cm in the ground floor and 56 cm in the frontispiece.

INTERNAL WALLS:

The original internal walls in the basement are half-timbered with approx. 5" x 7" timbers. The separating floors are borne by the longitudinal walls in the ground and first floors.

SEPARATING FLOOR:

The separating floors are timber joists without pugging, as this first became a requirement after a major fire in 1795. The beams are 8" wide full timbers, and are placed out from every brick pier.

ROOFING:

The load-bearing timber construction in the mansard roof is constructed with a beam division corresponding to the underlying floor joists. The roof is clad in red tiles.

CURRENT CONDITION

The many refurbishments of the building appear not to have resulted in serious settlement of the foundations. Cracks can be seen in the facade although in general the external surfaces of the building are in good condition. There could though of course be earlier cracks under the visible surface.

FUTURE USE OF THE BUILDING

The ground and first floors will be used for office purposes, with space for around 14 workstations. The ceiling height and daylight level in the basement means that this storey can only be used for secondary functions. The basement will therefore only contain a service area with kitchenette, with the other basement rooms offering opportunities for storage. The location of the plant room is maintained.
There are no canteen or meeting facilities in this building. These facilities will be available in building 11.

ENERGY CONSUMPTION (PER YEAR)

ORIGINAL CONSUMPTION:

Existing heating consumption:	28,39 MWh
Existing electricity consumption:	23,94 MWh

CALCULATED FUTURE CONSUMPTION:

Calculated heating consumption:	8,67 MWh
Calculated electricity consumption:	22,69 MWh
Calculated cooling load:	5,78 MWh

MEASURED CONSUMPTION AFTER ENERGY REFURBISHMENT*:

Measured heating consumption:	__,__ MWh
Measured electricity consumption:	__,__ MWh
Measured cooling load:	__,__ MWh

* These values will be collected once the building has been occupied (under normal load conditions) for more than a year.

STRUCTURAL SECTION – BUILDING 1

Building 4 – Office building towards Byghusgade

BBR:

Vester Kvarter,
København
246 – Building 4

AREA:

1158 m^2

HISTORY

The building was built in 1768, extended in 1819 and 1889, and has also been significantly altered several times, starting already in 1771.

The building is 18 bays long and two storeys high. The roof has a high pitch, in which the four chimneys and fire parapet stand out, with a half-hipped gable to the south and a standing gable to the north. There are 13 dormers towards the courtyard, 11 towards the street and also a number of skylights that provide light to a utilized roof storey. The plinth of the building is very low and one can therefore enter almost directly into the building.

After it was built the building was first used as a warehouse. A short time after construction the first alteration was started and residences and offices were gradually added in more and more of the building.
In several places the earlier room divisions are still visible and some room extents from the first conversion in 1771 are intact. In 1803 the office and residence functions were expanded again at the expense of the warehouse area. This expansion can still clearly be seen today, with fire walls and a fire parapet over the roof.

The almost level access is due to the earlier function of the building as a warehouse. The transport of materials required direct access into the warehouses, and the plinth has therefore always been low. In one place in the plinth there are cornerstones from an earlier gateway to the courtyard.
The long office building is the most complex of the buildings. It has been extended twice to the north, as well as the space being used for different functions such as warehouse, staff residences, archives, design studios and offices.
The complex building has heritage value in terms of both the layout and in the details from several periods. The structural differences are emphasised by a hierarchical and quality distinction between the newer, extended, northern part and the southern part containing residences. There are therefore consistent and well preserved room structures with ceiling cornicing, panelling and doors from the same period as the room structure.

The original longitudinal bearing system with posts/girders was replaced relatively early with a longitudinal masonry wall. The open warehouse rooms, lighted from one side, were replaced by smaller rooms on both sides of the longitudinal partition, with daylight from both facades. The secondary corridor structure has only recently been added.

Recently the building has been used for different office type functions. For example a corridor has been created throughout the building, as well as a safe room and technical solutions, which do not respect the values of the building.

FUNDAMENTAL HERITAGE VALUES

- Longitudinal partition walls
- Distinction between the northern and southern parts of the building
- Room structure unity
- Joinery details

The proposal for a restoration related approach to building 4 includes the conservation of valuable elements from different periods and restoration of older room structures.

STRUCTURE OF THE BUILDING

FOUNDATIONS:

The building has masonry foundations on oak piles.

OUTER WALLS:

The outer walls are solid brick with a thickness of two bricks in the ground floor and around 40cm (incl. rendering) in the first floor.

INTERNAL WALLS:

The internal walls are primarily solid brick walls. The longitudinal walls bear the load from the separating floors.

SEPARATING FLOOR:

The separating floors are timber joists without pugging, as this first became a requirement after the major fire in 1795. The beams are 8” wide full timbers.

ROOFING:

The roof is a traditional construction with collar-beam trusses. The roof is clad in red tiles.

CURRENT CONDITION

The many refurbishments of the building appear not to have resulted in serious settlement of the foundations. There are very few cracks at ground level, and the nature of those there are do not indicate serious problems with the foundations. Cracks can be seen in the facade, especially between the windows in the ground and first floors. The cracks are not very large, and have not resulted in any ingress of moisture. There are further cracks throughout the building, both internal and external. In a few places these are determined to be of interest in terms of their effect on the structural integrity of the building. These cracks are identified and recommended for further analysis.

FUTURE USE OF THE BUILDING

The building will be used for office purposes with space for around 75 workstations. The technical installations and entrance control system are designed so that the building can be divided into up to eight separate rental units. A common reception to receive guests will be created in the ground floor.
There are no canteen or meeting facilities in this building. These facilities will be available in building 11.

ENERGY CONSUMPTION (PER YEAR)

ORIGINAL CONSUMPTION:

Existing heating consumption:	97,09 MWh
Existing electricity consumption:	96,85 MWh

CALCULATED FUTURE CONSUMPTION:

Calculated heating consumption:	99,91 MWh
Calculated electricity consumption:	68,92 MWh
Calculated cooling load:	13,82 MWh

MEASURED CONSUMPTION AFTER ENERGY REFURBISHMENT*:

Measured heating consumption:	__,__ MWh
Measured electricity consumption:	__,__ MWh
Measured cooling load:	__,__ MWh

* These values will be collected once the building has been occupied (under normal load conditions) for more than a year.

STRUCTURAL SECTION – BUILDING 4

BUILDING 7, 8 AND 9 – MONOPITCH ROOF HOUSES

BBR:
Vester Kvarter, København 246 – Building 7, 8 and 9

AREA:
580 m^2

Building 7 Building 8 Building 9

HISTORY

Buildings 7 and 9 were constructed in 1819, building 8 in 1939.

Buildings 7, 8 and 9 are characterised by being built up against the back wall of the former civil service materials yard. They therefore have monopitch roofs and only receive daylight from the east and in the gable ends.

The buildings were designed and constructed as three separate volumes, but today effectively function as one building.
Buildings 7 and 9 were originally constructed on each side of a lime pit. Building 7 was built as a workshop building and building 9 as an open materials shed. Building 8 was built later as a link between the other two buildings, which at that time contained a design studio and offices.

When the middle building was constructed in 1939, building 7 to the right became known as the masonry workshop building and building 9 to the left the open masonry material shed. Building 9 is shown on Berggren's plan from 1887 as a timber building with three masonry sides, a front with 5 openings separated by timber columns and gable ends closed by short massive masonry walls. The openings are now filled in with masonry and contain eight windows, while a ninth window penetrates the left masonry wing. The heavy frame, which bore the roof over the five openings, can clearly be seen over the windows. The factory dormer was added possibly as late as 1970.

The workshop building originally had an opening in the middle of the facade, as well as two doors and two small windows which were later changed to the current large windows.

A significant share of the timber construction of posts and girders are preserved in both building 7 and 9, and the different functions of the original buildings can still be seen in the main structures.

The buildings have been renovated in several stages and their character significantly changed, with small-paned windows and subdivision of the rooms. The current cellular offices with plane doors and gloomy, unlit hallways against the back wall are a long way from the original, simple buildings with large open rooms and openings towards the courtyard.

The building has most recently been used for different office type functions, the layouts of which have not respected the values of the building.

FUNDAMENTAL HERITAGE VALUES

- Three building volumes
- Timber construction with very large dimensions

The situation with one-sided daylighting was originally not a problem, but today the spaces are subdivided and large areas are without daylight, so the rooms are not seen as quality spaces. It is especially difficult to see the heritage values in building 9 as the space has been heavily remodelled.

It is desired to restore the characteristics of the buildings as more or less open ‘sheds’ with clear constructions, few, simple details and a close relationship to the courtyard.

With the restoration it is planned to highlight the characteristic constructions as well as to renovate the facades, where the close relationship with large openings to the courtyard is to be restored. The new facades will have a uniquely contemporary styling since they are to be completely new elements. Due to the original character of the buildings the level of detail in the new layouts will be relatively simple.

The proposal for a restoration related approach to the buildings includes conserving and supplementing the constructive structures, reconstruction of the original façade openings and spaces as well as the addition of new facade elements.

STRUCTURE OF THE BUILDING

FOUNDATIONS:

The building has masonry foundations.

OUTER WALLS:

The outer walls are solid brick with various thicknesses. In the ground floor the end walls and facade towards the courtyard are 1½ - 2 bricks thick. The high back wall is also solid brick, but it was not possible to measure the thickness.

INTERNAL WALLS:

There are no original internal walls in this building. The existing walls are constructed as either lightweight walls or masonry.

SEPARATING FLOORS:

The separating floors are timber joists without pugging. The beams are 9½” x 9½” and are spaced per one metre. The floor deck is borne partly by the existing girders and partly by new masonry walls.

ROOFING:

The large monopitch roof on the building is borne by a console construction at the back of the building and a beam in the facade.

CURRENT CONDITION

There are horizontal cracks in the facade and gable end of building 7. These are to be investigated further.
Building 9 is characterised by several large, predominantly vertical cracks over the ground floor. The cause of these is to be investigated further. They could be due to settlement of the foundations (possibly due to the number of large trees in the area), or deterioration of joints in the masonry. The long masonry wall is also susceptible to movements due to temperature, which can cause cracks. There are also cracks in the facade of building 9 at ground level. These are most likely due to settlement of the foundations.
Cracks in the internal constructions can only really be seen in building 9.

FUTURE USE OF THE BUILDING

The ground and first floors will be used for office purposes, with space for around 30 workstations. The technical installations and entrance control system are designed so that the building can be divided into up to four separate rental units.
The second floor/attic will be used as a secondary space for storage.

ENERGY CONSUMPTION (PER YEAR)

ORIGINAL CONSUMPTION:

Existing heating consumption:	57,78 MWh
Existing electricity consumption:	26,57 MWh

CALCULATED FUTURE CONSUMPTION:

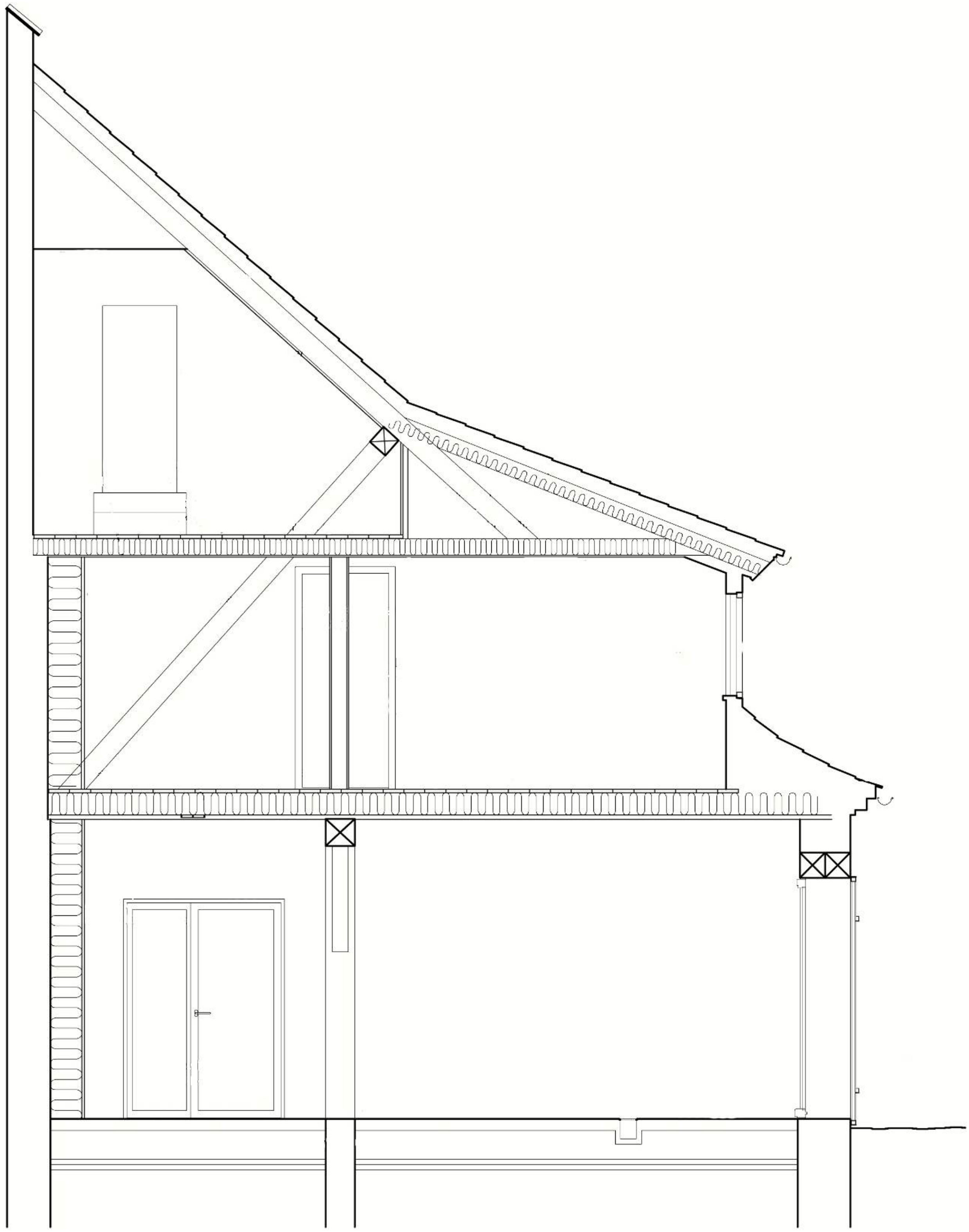
Calculated heating consumption:	30,71 MWh
Calculated electricity consumption:	22,95 MWh
Calculated cooling load:	6,69 MWh

MEASURED CONSUMPTION AFTER ENERGY REFURBISHMENT*:

Measured heating consumption:	__,__ MWh
Measured electricity consumption:	__,__ MWh
Measured cooling load:	__,__ MWh

* These values will be collected once the building has been occupied (under normal load conditions) for more than a year.

STRUCTURAL SECTION – BUILDING 7



BUILDING 11 – HALF-TIMBERED BUILDING

BBR:

Vester Kvarter,
København
246 – Building 11

AREA:

830 m^2

HISTORY

In 1748 the long half-timbered building was constructed along Vester Vold, now Vester Voldgade. It was designed as a warehouse as well as containing a small horse stable with six stalls.

The half-timbered building is 45 bays long and nine bays deep. The bays are remarkably small, around 1,1 m. The roof is clad in tiles and has a fall of around 50 degrees. Two lift dormers rise noticeably above the facade. The building is primarily orientated towards the courtyard due to the original function.

In the early 19th century there were major changes to the building, as well as the front dormer being moved. Only a few doors remain in the same place as when the building was built. The original placement of a few doors can still be read. The few original hatches are replaced by windows and there have been added many new bar windows.

In the original layout the horse stables lay in the eastern end and the rest of the building was divided into four large rooms. This gave a very open room structure, which was possible due to the internal timber structure having closely spaced columns. Originally the building had a very simple/rough level of detail, which fitted well with the function.

On the ground floor the building is still characterised by the large through-room and the post construction with main beams is, to a great extent, still preserved.

The main antiquarian and architectural values are the original beams on the ground floor. Unfortunately in the structure today there are many removed posts and corner braces, especially in the eastern part.

Two of the original half-timbered, crosswise walls in the ground floor are preserved, and they provide a lot of antiquarian value as part of the original room structure. The original detailing includes wood joinery, doors, openings and shutters.

Recently the building has been used for different office type functions, the layouts of which have not respected the values of the building.

FUNDAMENTAL HERITAGE VALUES

- Storehouse character
- The two longitudinal beam systems
- Simple/rough detailing

The storehouse character of the building, with clear constructions and rough, simple detailing, as well as the close relationship with the courtyard, will be emphasised and strengthened through the restoration.
Internally the building will therefore primarily contain parts from the original construction and new elements from 2009. The period in between is considered to be less meaningful when seen from an antiquarian and architectural point of view.

STRUCTURE OF THE BUILDING

FOUNDATIONS:

The building has masonry foundations. However the building shows signs of large deformations. It is clear that the deformations have occurred due to settlement in the foundations.

OUTER WALLS:

The outer walls are half-timbered with a total of 45 bays.

INTERNAL WALLS:

The building was originally built with two crosswise, masonry walls and no other internal walls. The walls that were added later are of light construction.

SEPARATING FLOORS:

The separating floors are timber joists without pugging. The beams are 8” wide, solid timber and are part of the girder system in the ground floor.

ROOFING:

The roof is built as a pitched roof with collar-beam trusses. The roof is clad in red tiles.

Current Condition

The building is characterised by large deformations, both horizontal and vertical. However, based on the resultant cracks, the building as a whole is assessed to be relatively stable. The deformations must be from a while ago.

The timber constructions have been regularly maintained. A number of repairs and replaced timbers can be seen in the external timbering. Splits in the facade can be seen around the newest timbers, due to the shrinking of the wood. These can give access to moisture which can damage the timber.

Internally there can be seen cracks in the in-situ ground slab and walls around the gate. These are clearly due to settlement of the ground, probably due to the sewer pipes which run through the gate.

Future use of the building

The ground floor of the building will be used as a service area for the other buildings. One half of the building is designed for meeting facilities. In the other, less intact, half of the building, canteen and kitchen facilities will be created. This is due to the fact that this half of the building can, in terms of heritage values, better tolerate the necessary large changes.

The first floor will be used for office purposes, with space for around 28 workstations. The technical installations and entrance control system are designed so that the area can be divided into two separate rental units.

Energy consumption (per year)

Original consumption:

Existing heating consumption:	99,44 MWh
Existing electricity consumption:	40,86 MWh

Calculated future consumption:

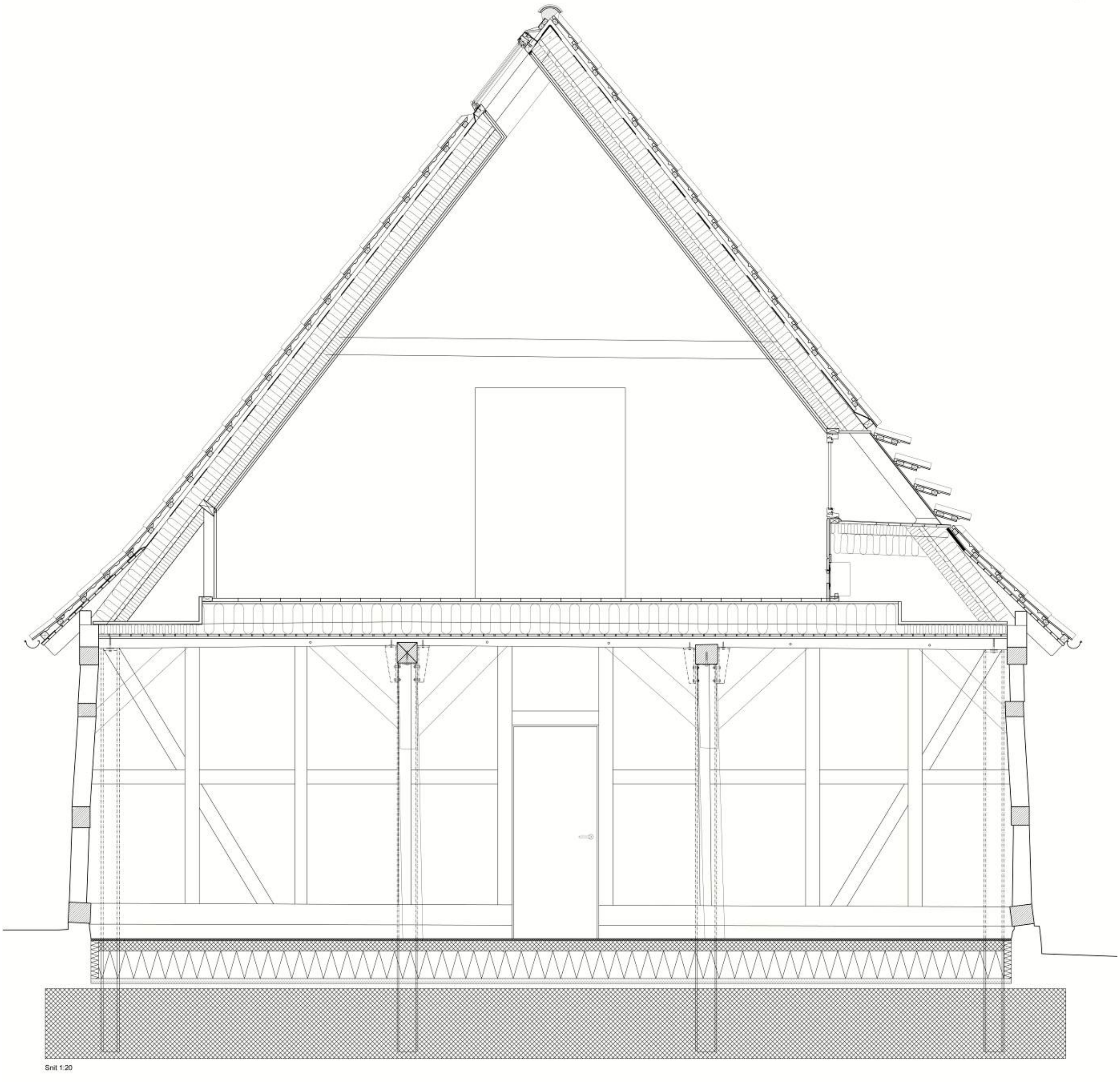
Calculated heating consumption:	39,58 MWh
Calculated electricity consumption:	64,61 MWh
Calculated cooling load:	14,78 MWh

Measured consumption after energy refurbishment*:

Measured heating consumption:	__,__ MWh
Measured electricity consumption:	__,__ MWh
Measured cooling load:	__,__ MWh

* These values will be collected once the building has been occupied (under normal load conditions) for more than a year.

STRUCTURAL SECTION – BUILDING 11



PROPOSALS FOR ENERGY SAVING INITIATIVES

The proposals for energy saving initiatives were drafted via a selection of potential energy-efficient initiatives. The proposals should be well known initiatives, which are a proven product/solution and have the necessary documentation for function and use. This project will deal with the available solutions which could potentially be implemented in listed buildings.

The solutions are split into 3 groups:

- Passive elements
- Active elements
- Design considerations

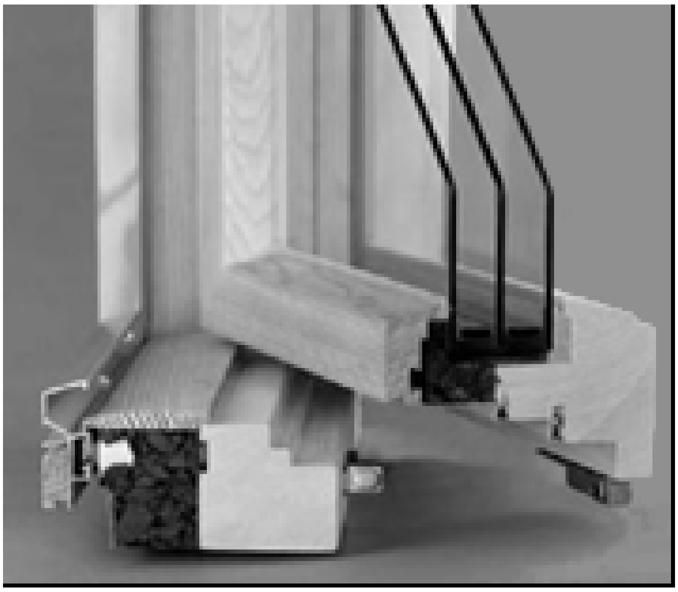
This chapter contains a description of the selected initiatives, their desired effect as well as the initial comments from the project team.
The desired effect was not calculated at this point.

PASSIVE ELEMENTS

NO. 01A NEW WINDOWS

DESCRIPTION

Replacing with new windows.
Super low energy, possibly with “false mullions”.



DESIRED EFFECT

Minimisation of heat loss.
Solar screening in glass.
Minimisation of cold bridges.

EXTENT/IMPLEMENTATION

Windows in all floors replaced with new windows with low energy glass. Internal follow up work will be carried out such as adjustment of openings and frames.
The glass is slightly tinted. The frame has a larger dimension than the original. Mullions performed as false mullions.

COMMENTS:

HERITAGE AGENCY

The windows in building 1, 4 and 11 are original, or at least old, and form an important part of the core heritage value of the building.
As a starting point the old windows should be restored instead of replaced. Complete replacement can only be accepted if the windows are very damaged. Potential new windows should be careful copies of the old windows with the same single glazing, glazing rebates, profile details and window furniture.

ARCHITECT

The windows in building 1, 4 and 11 have a high heritage value and cannot be replaced by new windows. The dimensions of the current windows fit in with the building. New windows will be significantly heavier due to the thickness of the glass.

INITIAL ASSESSMENT

The existing windows will, in general, not be replaced as the heritage value is regarded more highly than lowering energy use.

NO. 01B WINDOWS IN NEW HOLES

DESCRIPTION

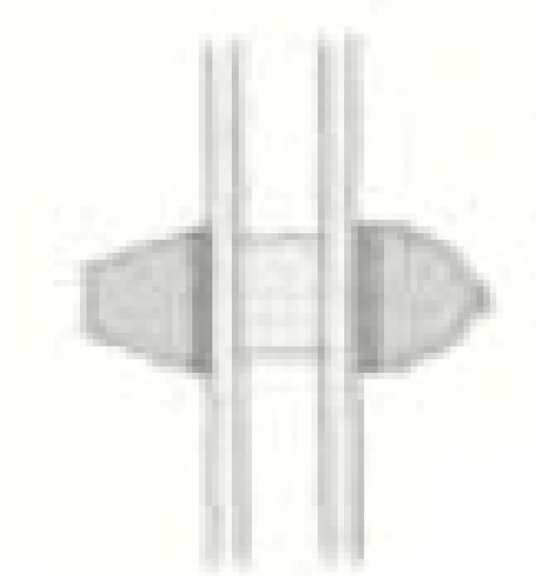
New windows in new holes.
The windows performed as super low energy windows, possibly with false mullions. Possibly performed in timber/plastic composite windows.

DESIRED EFFECT

Minimisation of heat loss.
Solar screening in glass.
Minimisation of cold bridges.

EXTENT/IMPLEMENTATION

Windows in all floors replaced with new windows with low energy glass. The glass is slightly tinted.
The frame has a larger dimension than the original. Mullions performed as false mullions.
Internal follow up work such as adjustment of openings and frames carried out.



FALSE MULLION

COMMENTS:

HERITAGE AGENCY

The windows should respect the existing pattern of the facade.

ARCHITECT

Low energy windows could be an option if new window holes are created in the facades, as long as the frame dimensions and the colour of the glass are architecturally acceptable.

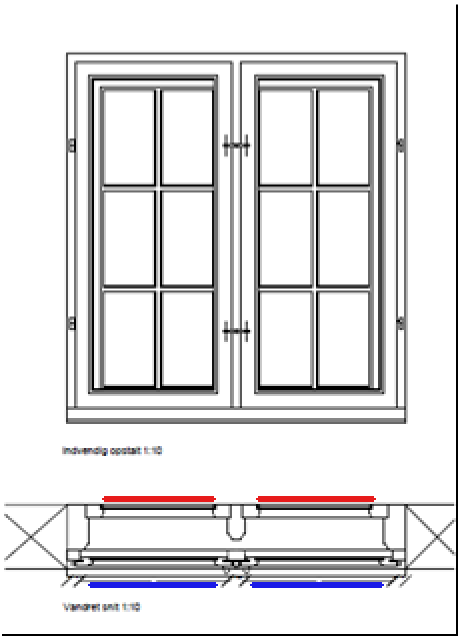
INITIAL ASSESSMENT

In general nothing should be included in the building which appears to be something which it is not. There is therefore a general consensus that false mullions should not be used.

No. 02 New energy efficient secondary glazing. Plus solar shaded external glazing.

Description

Glass in secondary glazing replaced with energy efficient glass.
Glass in the external frame replaced with solar shaded glass.



Desired Effect

Minimisation of heat loss.
Solar screening in glass.
Minimisation of cold bridges.

Extent/Implementation

The existing clear secondary glazing replaced with new, lightly toned energy efficient glass. The internal secondary frame renovated. The external glazing is replaced with solar shaded glass.

Comments:

Heritage Agency

Energy efficient glass is a possibility as long as the actual joinery, fittings and the colour of the glass can be accepted.

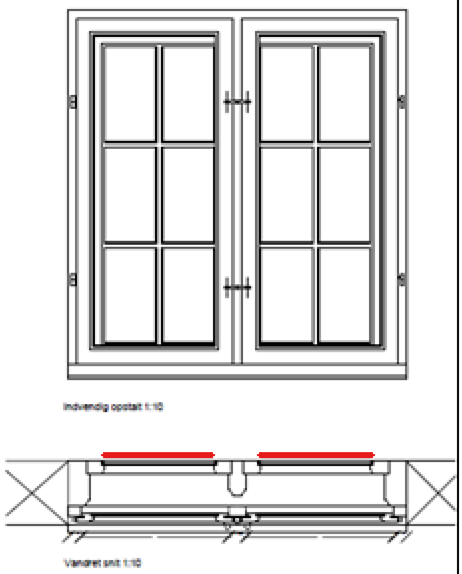
Architect

Seemingly ok. This assumes that in each individual case the dimensions of the secondary glazing frames and colour of the glass can be adapted to the existing architecture.

Initial assessment

It was not possible to find an external solar shaded glass which does not create inappropriate reflections. This initiative is therefore rejected.

NO. 02A NEW ENERGY EFFICIENT SECONDARY GLAZING



DESCRIPTION

The glass in the secondary glazing is replaced with new energy efficient glass.

DESIRED EFFECT

Minimisation of heat loss.
Minimisation of cold bridges.

EXTENT/IMPLEMENTATION

The existing clear secondary glazing is replaced with new, lightly toned, energy efficient glass. The internal secondary frames are renovated.

COMMENTS:

HERITAGE AGENCY

Energy efficient glass is a possibility as long as the actual joinery, fittings and the colour of the glass can be accepted.

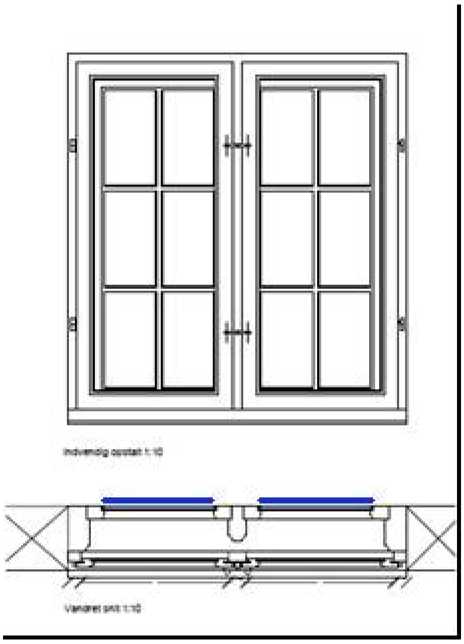
ARCHITECT

Seemingly ok. This assumes that in each individual case the dimensions of the secondary glazing frames and colour of the glass can be adapted to the existing architecture.

INITIAL ASSESSMENT

A type of glass was found which with a colour tone that is acceptable.

No. 02B Solar shaded secondary glazing



Description

The glass in the secondary glazing is replaced with new solar shaded glass.

Desired Effect

Minimisation of heat loss.
Minimisation of solar radiation.
Minimisation of cold bridges.

Extent/Implementation

The existing clear secondary glazing is replaced with new, lightly toned, solar shaded glass. The internal secondary frames are renovated.

Comments:

Heritage Agency

Solar shaded glass is a possibility as long as the actual joinery, fittings and the colour of the glass can be accepted.

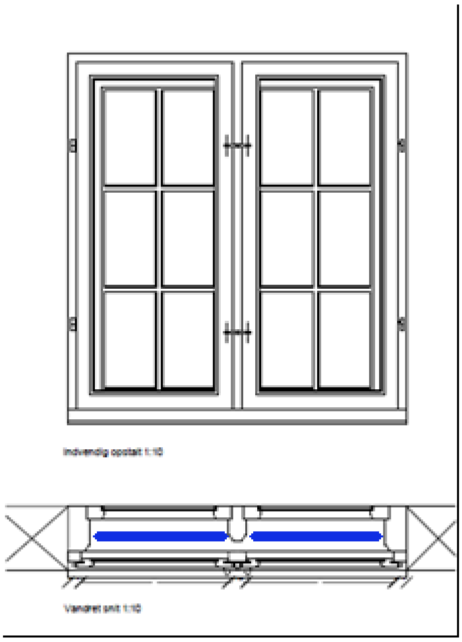
Architect

Seemingly ok. This assumes that in each individual case the dimensions of the secondary glazing frames and colour of the glass can be adapted to the existing architecture.

Initial assessment

A type of glass was found with a colour tone that is acceptable. The initiative was not financially viable.

NO. 03 NEW WINDOWS WITH INTERNAL SOLAR SCREENING.



DESCRIPTION

Replacing windows with new windows with internal solar screening.

DESIRED EFFECT

Minimisation of heat loss.
Minimisation of cold bridges.
Active control of solar shading.

EXTENT/IMPLEMENTATION

New windows on the sunny side equipped with internal active solar screening.

COMMENTS:

HERITAGE AGENCY

Integrated solar shading in an historic window can not be accepted.
According to the Building Conservation Act the Heritage Agency has no authority to refuse permission for removable components such as blinds and curtains. These can also be used as internal solar shading but are not of a permanent nature.

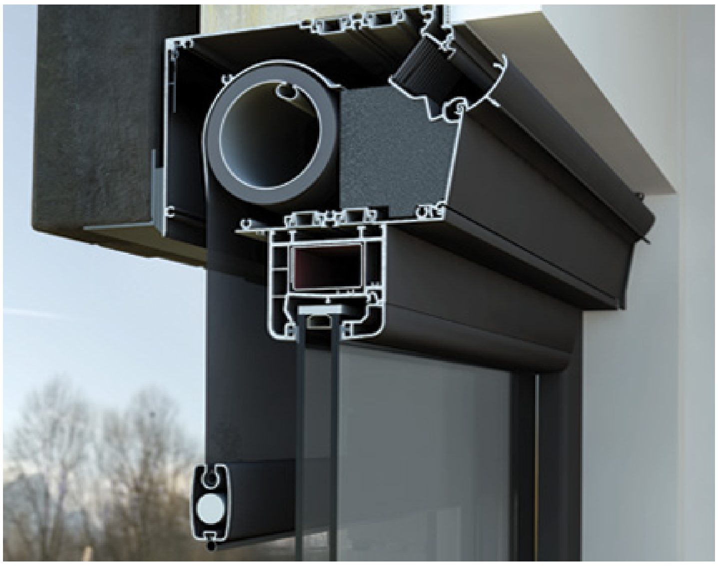
ARCHITECT

The architectural impact of blinds between the window and the secondary glazing is too large for the solution to be acceptable. It can also not be accepted to replace the window entirely with a window where blinds are an integrated element.

INITIAL ASSESSMENT

The initiative is rejected as the windows are a significant part of the core heritage values of the building.

NO. 04 EXTERNAL SOLAR SHADING.



DESCRIPTION

Awning solutions and other external screening possibilities.

DESIRED EFFECT

Active control of solar radiation.

EXTENT/IMPLEMENTATION

New windows on the sunny side equipped with external active solar screening.

COMMENTS:

HERITAGE AGENCY

New shutters or awnings can not be accepted on Building 1 and in general cannot be accepted on listed buildings, as external solar shading will dramatically change the character of the facade which here, as is usually the case, is part of the core heritage value of the building.

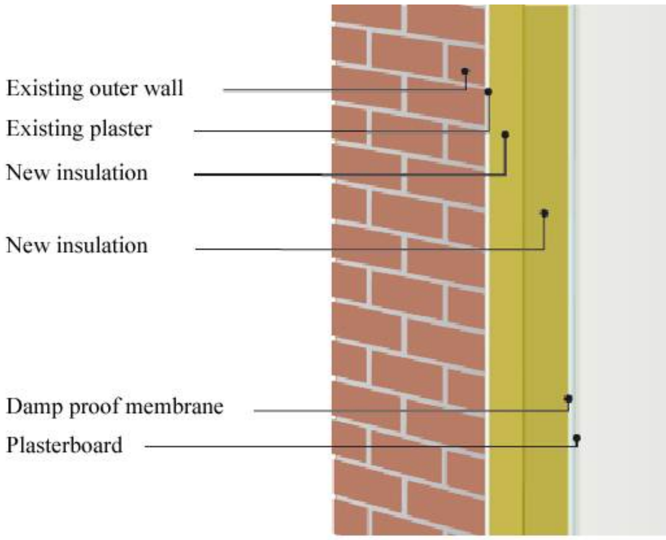
ARCHITECT

External shutters are already found on the basement windows, these will remain on the building. Awnings over the ground and first floor windows can not be accepted – these would be a foreign element to the building.

INITIAL ASSESSMENT

The initiative is rejected for building 1 and 4. Different solar shading solutions are investigated for building 7/8/9 and 11.

NO. 05 INTERNAL POST-INSULATION OF OUTER WALLS.



DESCRIPTION

Internal insulation of existing outer walls.

DESIRED EFFECT

Minimisation of heat loss.

EXTENT/IMPLEMENTATION

Post-insulation of outer walls. Panels and frames moved out to the new wall position.

COMMENTS:

HERITAGE AGENCY

The moving of panels and frames can not be accepted, as destructive interference in the historical materials is, in general, not acceptable.
In some cases it can be acceptable to create an insulated secondary wall, but only in secondary rooms and if there are no panels or other historical details. In this actual building it is assessed that this could possibly be an option in the basement and on the first floor, where there is already insulation.

ARCHITECT

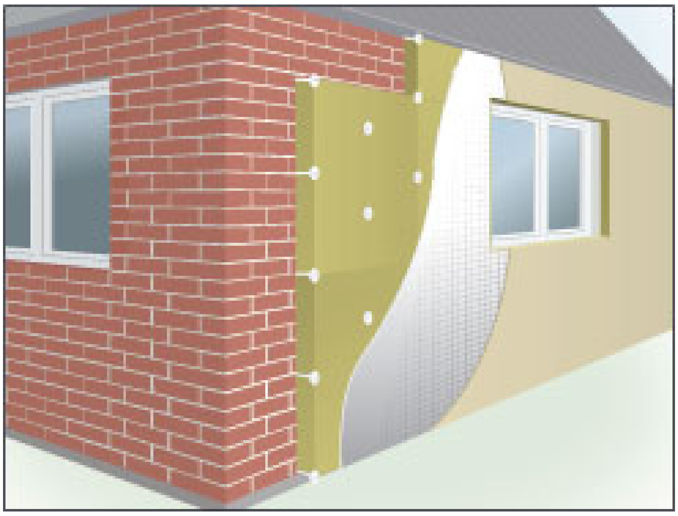
The moving of panels and frames can not be recommended, as they would have to be adapted to new, smaller room dimensions, which would negatively intervene in the room's whole.

Engineer
When post-insulating internally attention should be paid to the change in moisture balance in the materials of the outer wall (timber and masonry). It should also be ensured that the joins with adjacent building components can be appropriately carried out (e.g. with regard to thermal bridges at windows etc.). Relevant guidance can be found from the Danish Agency for Culture and the Centre for Building Preservation.

INITIAL ASSESSMENT

Only implemented in secondary rooms and places where the walls do not have a heritage value.

NO. 06 EXTERNAL POST-INSULATION OF OUTER WALLS



DESCRIPTION

External post-insulation of the existing outer walls.

DESIRED EFFECT

Minimisation of heat loss

EXTENT/IMPLEMENTATION

All outer walls externally post-insulated with rendering. Follow-up work such as new windows sill etc.

COMMENTS:

HERITAGE AGENCY

External post-insulation can not be accepted, as it would change the character of the facades of the building, which are part of the core heritage values of the building.

ARCHITECT

The architecture of the building will be clearly changed with an external post-insulation.

ENGINEER

The potential for a change in the moisture conditions in the construction should be considered. It should also be ensured that the structure can bear the extra load.

INITIAL ASSESSMENT

Rejected.

NO. 07 POST-INSULATION OF SLOPED CEILINGS.

DESCRIPTION

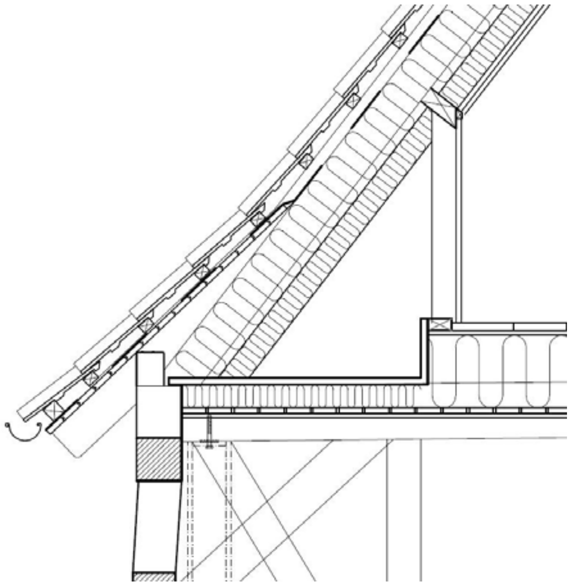
Insulation thickness increased

DESIRED EFFECT

Minimisation of heat loss.

EXTENT/IMPLEMENTATION

Ceiling and eaves void is post-insulated.
Walkways etc. are raised.
Sloped ceilings lowered.



COMMENTS:

HERITAGE AGENCY

Internal insulation of an ”appropriate” dimension in the eaves and sloped walls is acceptable in the attic, as it is currently unused.

ARCHITECT

Internal insulation of the sloped ceilings is acceptable, as long as it does not have too large an architectural consequence in the rooms it affects.

ENGINEER

Consideration should be given to potential changes to the moisture conditions in the construction. It should also be ensured that the structure can bear the extra load.

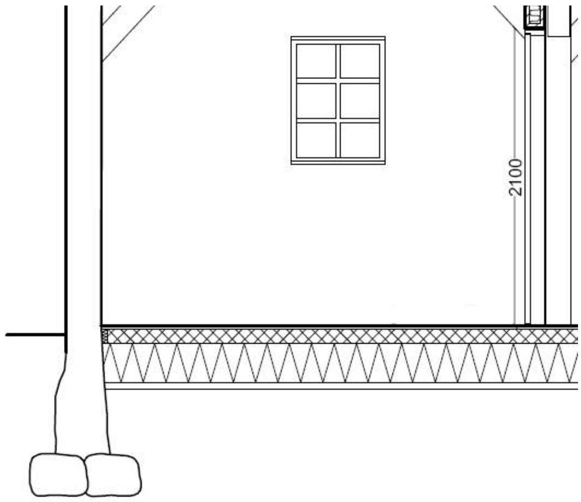
INITIAL ASSESSMENT

Increased insulation in the sloped ceilings should be implemented in buildings 7/8/9 and 11.

NO. 08 POST-INSULATION OF GROUND SLAB.

DESCRIPTION

Post-insulation of ground slab.



DESIRED EFFECT

Minimisation of heat loss.

EXTENT/IMPLEMENTATION

The old ground slab is broken up, new capillary barrier and insulation laid down. Foundations cast in the necessary places.

COMMENTS:

HERITAGE AGENCY

Post-insulation of the ground slab in the basement level can generally be accepted, as there are no important heritage values immediately associated with the basement floor.
The city museum should be notified when excavation works are carried out and monitoring should take place to check if there can be found any building/archaeological traces.

ENGINEER

A new ground slab would normally entail excavation down to around 50 cm under the future floor level. It should be ensured that the foundations – especially where there are stone foundations – are not undermined. Consideration should also be given to the fact that this initiative can result in a large, temporary, rise in moisture level in the other building elements. During construction it should be taken into account that the existing ground slab currently takes the earth pressure from the basement walls.
The joints in the transition from the plinth to the floor slab should be secured against radioactive gasses rising from the ground (e.g. radon).

INITIAL ASSESSMENT

Should only be implemented if the ground slab will be replaced anyway due to other reasons.

No. 09 Use of new ‘super thin’ insulation type.

Description

Use of thin insulation forms.

Desired Effect

Minimisation of heat loss.

Extent/Implementation

Existing dormer cheeks insulated with the thin insulation.

Comments:

Heritage Agency

As long as the insulation can fit in to the existing windows, wall etc. can post-insulation with a highly insulating material be accepted.

Engineer

The effect of the insulation is not certain, and correct placement requires a layer of air on both sides, whereby the overall thickness of the insulation will be almost the same as traditional insulation. It has not been possible to find reliable calculation methods with which to evaluate this initiative.

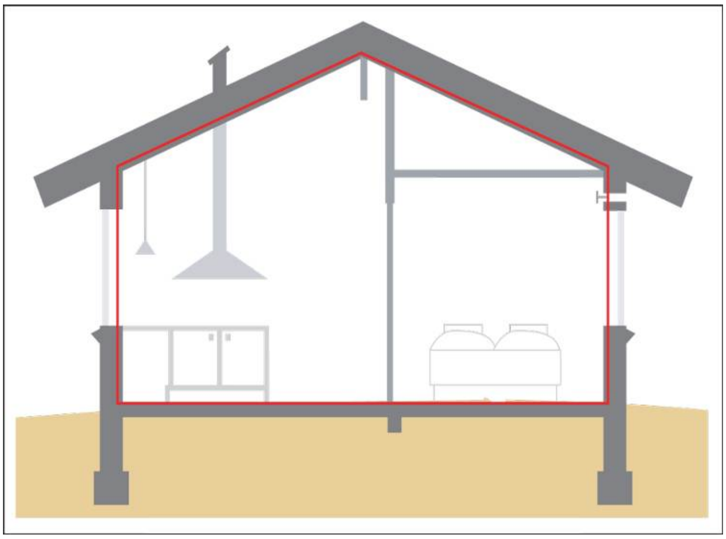
Initial assessment

Rejected.

NO. 10 IMPROVEMENT OF BUILDING AIR TIGHTNESS.

DESCRIPTION

Building envelope investigated for leaks.



DESIRED EFFECT

Verified air change rate in the buildings.
Minimisation of heat loss.
Minimisation of risk of rot in the construction.

EXTENT/IMPLEMENTATION

Detected leaks around wall joints, openings/frames etc. closed.
Panels, openings and frames demounted and the building envelope closed.

COMMENTS:

HERITAGE AGENCY

Work to reduce the permeability of the existing building can be accepted as long as it is in general the same as the existing, for example carried out with the same materials, colours and details as well as with traditional materials and techniques. In this case the work would come under the heading "normal maintenance".
Handling of the historic building must be done with care.

ENGINEER

The initiative could be implemented, and would lead to a reduced risk of local, unintended rises in moisture level in building components with serious leakages. If the initiative results in the air change rate in the building being too low this should be compensated for via controlled air exchange (natural ventilation or ventilation units).

INITIAL ASSESSMENT

All work connected to the building envelope should be performed so that the envelope is as tight as possible.

ACTIVE ELEMENTS

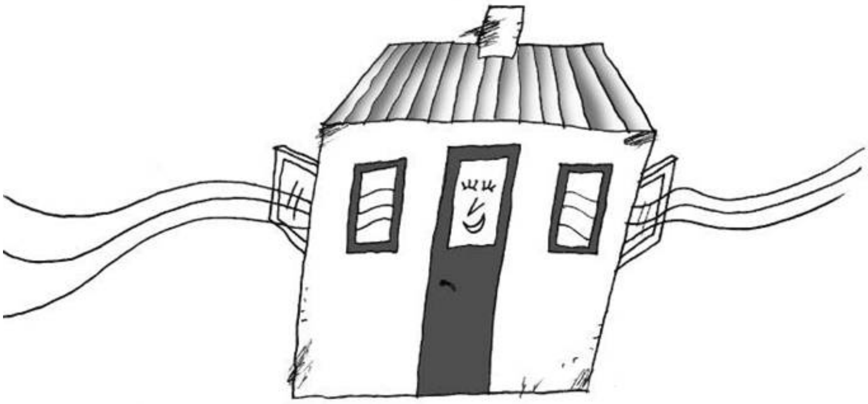
NO. 11 VENTILATION SYSTEM, NATURAL.

DESCRIPTION

Ventilation of rooms via opening windows.

DESIRED EFFECT

Demand/manually controlled ventilation.
Minimal plant and operating costs.



COMMENTS:

HERITAGE AGENCY

Windows are made to see through and to allow light and air in.

ENGINEER

Ventilation of the rooms via the windows can be utilised in single offices. In larger offices there should be mechanical ventilation.

INITIAL ASSESSMENT

The solution can only be implemented in rooms designed for one or two people. Mechanical ventilation should be implemented in room designed for more people.

NO. 12 VENTILATION SYSTEM, HYBRID.

DESCRIPTION

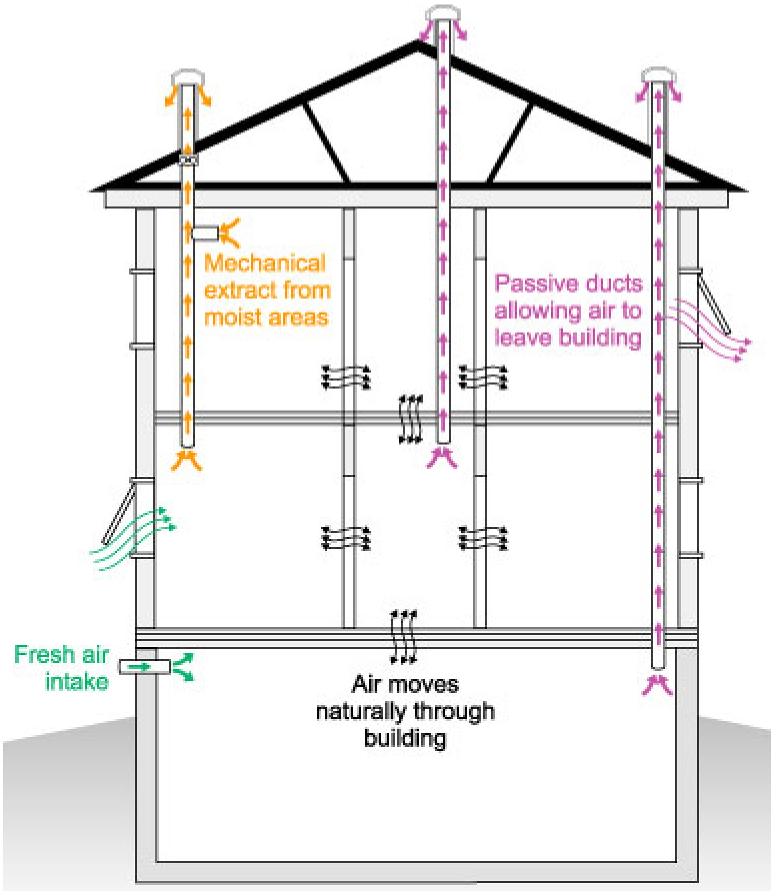
Ventilation of rooms via fresh air intake through the building envelope and extraction over the roof.

DESIRED EFFECT

Controlled ventilation that ensures the required air change rate.

EXTENT/IMPLEMENTATION

A central extraction system is created with exhaust out through the existing chimney.
A service route is created down through the different stories, as well as service routes on every floor out to every room.
Fresh air supplied through fresh air ventilators in the windows.



COMMENTS:

HERITAGE AGENCY

Exhaust through the chimney is acceptable. Service routes through the ''grand' rooms on the ground floor is unlikely to be possible.
Standard fresh air ventilators in the windows can not be accepted.
In some situations an architecturally developed solution, with replacement of one frame or one pane with a fresh air intake, can be accepted in the basement windows.
A solution with a fresh air supply under ground is also an option.

ARCHITECT

If the exhaust from the extraction unit can go through the chimney then that part is ok. Then it is the supply air that is problematic. Suspended ceilings can not be accepted in the rooms where there is stucco, and the room extents also have architectural value which cannot be altered.
The only option is therefore to create visible supply routes in the rooms. Due to the character of the spaces this solution cannot be accepted in very many rooms. Some rooms can therefore not be supplied. The solution is ok in secondary rooms with suspended ceilings – bathrooms.

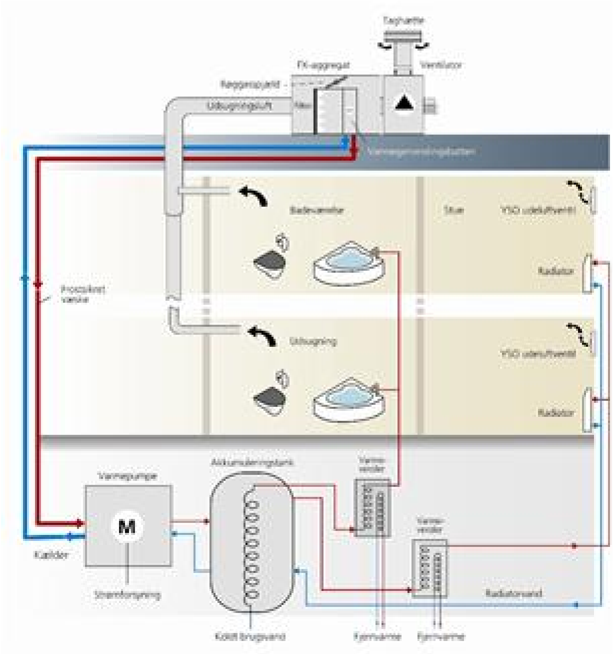
INITIAL ASSESSMENT

The initiative is rejected as it is not possible to create a fresh air intake in the facade.

NO. 13 VENTILATION SYSTEM, HYBRID COMBINED WITH HEAT PUMP.

DESCRIPTION

Ventilation of rooms via fresh air intake through the building envelope and extraction via a heat pump with exhaust through the roof.



DESIRED EFFECT

Controlled ventilation that ensures the required air change rate, together with heat recovery from the exhaust air.

EXTENT/IMPLEMENTATION

As in no. 12.
Extraction unit supplied with a heat pump. Heat is transferred from exhaust air to the heating system.

COMMENTS:

HERITAGE AGENCY

As in no. 12.

ARCHITECT

As in no. 12.

ENGINEER

Heating system should be a low temperature system in order to be able to use heat recovery from the exhaust air.

INITIAL ASSESSMENT

The initiative is rejected as it is not possible to create a fresh air intake in the facade.

NO. 14 VENTILATION SYSTEM, TRADITIONAL.

DESCRIPTION

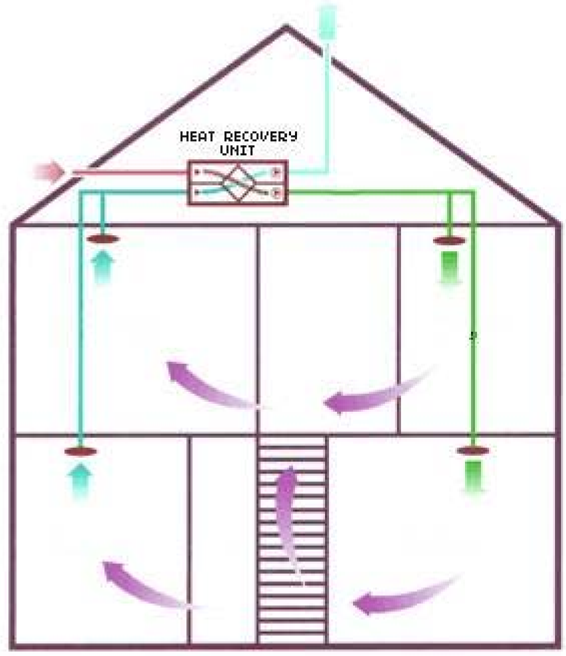
Rooms ventilated with forced ventilation and extraction via a ventilation system.

EFFECT

Controlled ventilation that ensures the required air change rate, as well as controlled supply air temperature to the rooms.
Potential for cooling via supply air.

EXTENT/IMPLEMENTATION

A ventilation unit is placed in the attic. Intake and exhaust through the roof.
A service route is created down through the building, as well as routes out to every room.



COMMENTS:

HERITAGE AGENCY

A prerequisite for this type of ventilation system is that ducts are laid to the individual rooms in the building.
Laying ducts to all of the rooms is not possible, as this would require destructive intervention in the heritage value details such as stucco and carpentry, and thereby a degradation of the heritage value of the building.

ARCHITECT

If the exhaust from the extraction unit can go through the chimney then that part is ok. Then it is the supply air that is problematic
Suspended ceilings can not be accepted in the rooms where there is stucco, and the room extents also have architectural value which cannot be altered.
The only option is therefore to create visible supply routes in the rooms. Due to the character of the rooms this solution cannot be accepted in very many rooms. Some rooms can therefore not be supplied. The solution is ok in secondary rooms with suspended ceilings – bathrooms.

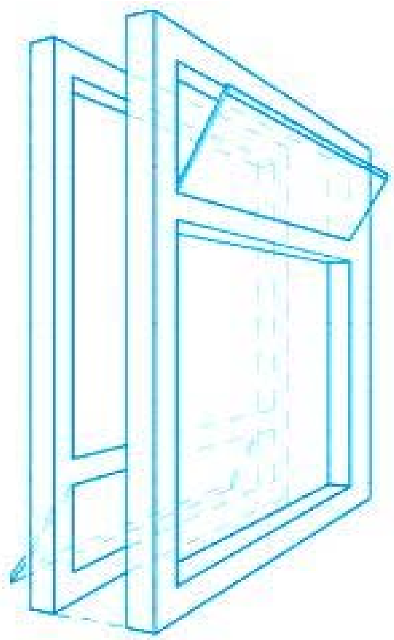
ENGINEER

The required air change rate according to the Danish Working Environment Authority is ensured when mechanical ventilation is used.

INITIAL ASSESSMENT

Supply routes for mechanical ventilation cannot be placed in buildings 1 and 4. The solution will be implemented in buildings 7/8/9 and 11.

NO. 15 FRESH AIR INTAKE VIA SOLAR WALLS, ACTIVE GLAZING



DESCRIPTION

Heating the fresh air supply via solar walls or active glazing.

DESIRED EFFECT

Use of solar energy for heating of fresh air.

EXTENT/IMPLEMENTATION

A solar wall is created on the southern gable end with fresh air intake inside the building. The fresh air is then supplied to each separate room.

COMMENTS

HERITAGE AGENCY

The solar collector will be an obvious foreign element on the facade of the listed building and therefore impairs the core heritage values of the building.

ARCHITECT

The exterior of the building possesses an architectural whole which should be conserved. A solar wall stand out from the materials of the building and will therefore impair the whole.

ENGINEER

In combination with a controlled extraction system the solution can ensure heating of the supplied fresh air.

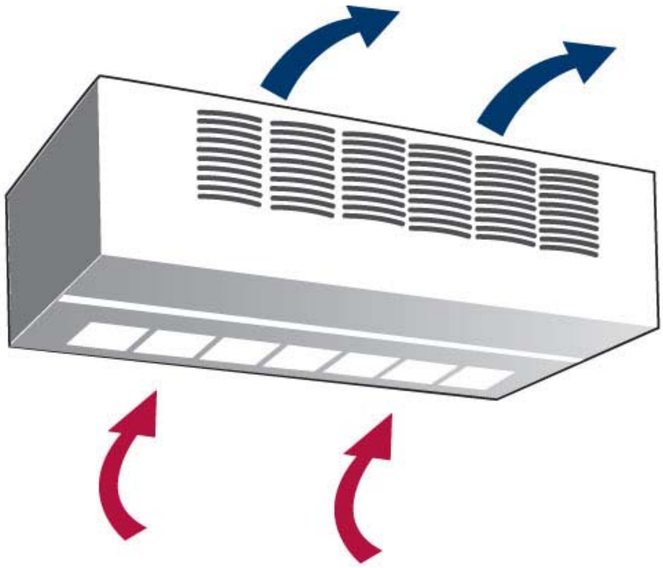
INITIAL ASSESSMENT

Can not be implemented without visible solar panels.

NO. 16 COOLING, VIA RECIRCULATION OF AIR IN THE RELEVANT ROOMS.

DESCRIPTION

A unit is placed in the room which re-circulates the air, and can be operated individually for each room.



DESIRED EFFECT

Quick adjustment.
Can be combined with heating.

EXTENT/IMPLEMENTATION

A unit which cools and re-circulates the air is placed at floor level in every room with a cooling demand.

COMMENTS:

HERITAGE AGENCY

In general it is not acceptable to build mechanical units into the historical components of the building.
In the event that consent is given for new secondary walls or new floor, and there is space in these, the solution can be considered.

ENGINEER

Cooling via air recirculation increases the opportunity for individual control, as well as ensuring a minimal installation(should obviously be correctly sized). Energy use associated with cooling is independent of which method is used.

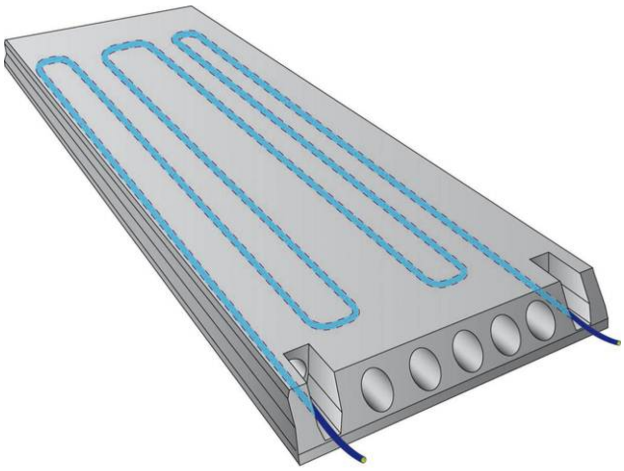
INITIAL ASSESSMENT

The group will investigate to find a solution which can be implemented in harmony with the building.

NO. 17 COOLING, VIA PASSIVE COOLING.

DESCRIPTION

Cooling is provided via a chilled ceiling or wall.



DESIRED EFFECT

Minimum air transport and therefore minimum potential for draughts.

EXTENT/IMPLEMENTATION

A new ceiling with passive cooling is installed.

COMMENTS:

HERITAGE AGENCY

The rooms on the ground floor can not be adapted to passive cooling without compromising the heritage value of the building.
The initiative can be considered in the basement and 1st floor.

ARCHITECT

The ceilings in building 1 are an important part of the architecture. Therefore suspended ceilings, which air routes could be placed, cannot be used.

ENGINEER

Due to the listed status and architectural issues it is not possible to use the ceilings or walls to implement passive cooling.

INITIAL ASSESSMENT

Rejected.

NO. 18 COOLING, AIR SOURCE HEAT PUMP.

DESCRIPTION

Cooling where surplus heat is removed to the outside air.

DESIRED EFFECT

Minimal operating costs.

EXTENT/IMPLEMENTATION

The cooling unit and condenser are placed in the attic. Intake and exhaust for the cold air to the condenser are provided.

COMMENTS:

HERITAGE AGENCY

Intake and exhaust through the chimney is acceptable. Supply through the 'fine' rooms in the ground floor is unlikely to be possible.
Intake and exhaust through windows is not acceptable.
In individual cases an architecturally developed solution, such as the replacement of a frame or singles pane with fresh air intake/exhaust, can be accepted in basement windows.
A solution with intake and exhaust under ground is also a possibility.

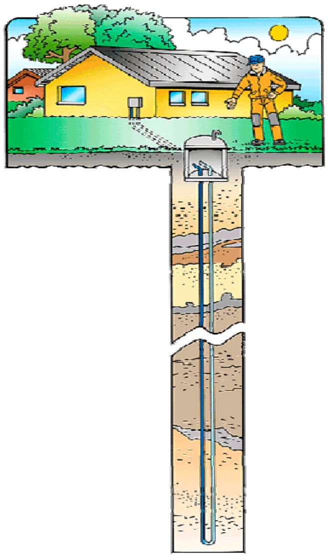
ENGINEER

Low initial costs and an achievable COP factor (ratio of heat output to heat input) of 3. The unit requires large volumes of air moving over the unit.

INITIAL ASSESSMENT

The most economically viable solution.

NO. 19 COOLING, GROUND SOURCE HEAT PUMP.



DESCRIPTION

Cooling where surplus heat is removed to the ground via buried pipes.

DESIRED EFFECT

Potential for free cooling, minimal noise.
Good COP factor (ratio of heat output to heat input).

EXTENT/IMPLEMENTATION

Cooling unit is placed in the basement. The pipes are drilled or laid out in the courtyard area.

COMMENTS:

HERITAGE AGENCY

Ground pipes that are laid through the foundations and lie under ground can be a possibility, as long as the structural state of the building is taken into account, as well as the paving in the listed courtyard.

ARCHITECT

Under the assumption that the listed paving in the courtyard is respected.

ENGINEER

Horizontal ground pipes are to possible due to the limited area of the complex. Vertical bored pipes can be used instead. However they require that there is an aquifer water table. This should be investigated via a geotechnical survey.

INITIAL ASSESSMENT

Rejected.

NO. 20 COOLING, GROUND/SEAWATER HEAT PUMP.

DESCRIPTION

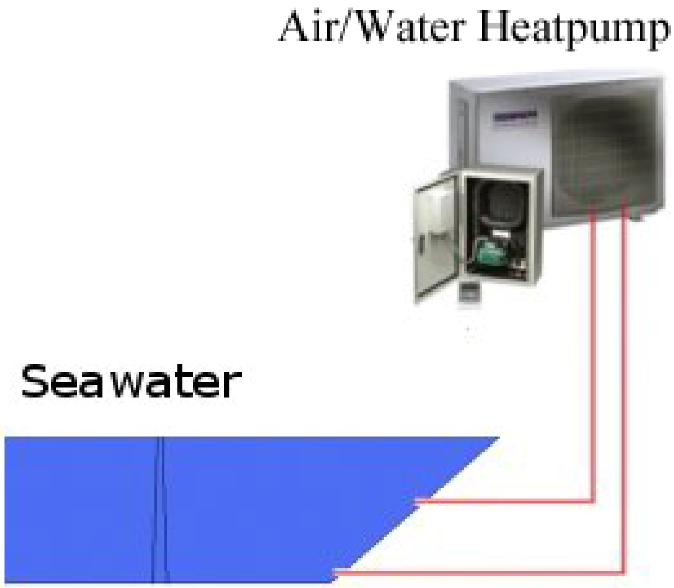
Cooling where surplus heat is removed to sea or ground water.

DESIRED EFFECT

Potential for free cooling, minimal noise.
Very good COP factor (ratio of heat output to heat input).

EXTENT/IMPLEMENTATION

Cooling unit for all 4 buildings is placed in the basement in building 1. Cold water is taken from Frederiksholm Canal. A cold water distribution system between the buildings is built.



COMMENTS:

HERITAGE AGENCY

Cooling pipes laid through the foundations could be a possibility, as long as the structural state of the building is taken into account. The listed paving should also be considered, as well as the actual size of the plant, which should be assessed relative to the size available in the basement.

ARCHITECT

Under the assumption that the listed paving in the courtyard is respected.

ENGINEER

The initiative is not financially viable due to the relatively low cooling load and high initial costs

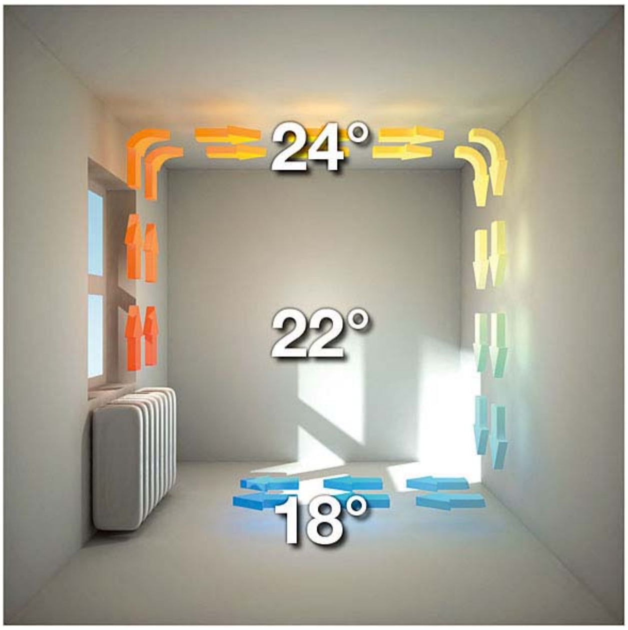
INITIAL ASSESSMENT

Rejected.

NO. 21 HEAT SOURCE, RADIATOR.

DESCRIPTION

Heating provided via ’traditional’ radiator heating.



DESIRED EFFECT

Good potential for individual heating.
Quick adjustments.
Can counteract drafts from cold surfaces.

EXTENT/IMPLEMENTATION

The heating system type in the building is retained.
With respect to the new layout the radiators should preferably be placed under windows to prevent condensation.

COMMENTS:

HERITAGE AGENCY

Traditional radiators could be a possibility. The choice of radiators and placing of heating pipes should show regard for the architecture of the building, as well as the panelling and stucco.

DEVELOPER

A heating method the same as the existing. Easy to understand/use for tenants.

ENGINEER

Good opportunities for individual heating. Quick to adjust. Can counteract condensation from cold surfaces.

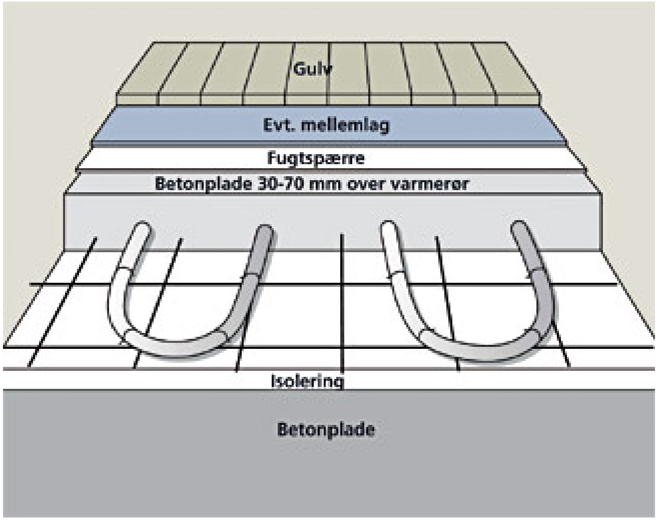
INITIAL ASSESSMENT

Initiative implemented when under floor heating or fancoil units are not.

NO. 22 HEAT SOURCE, UNDERFLOOR HEATING.

DESCRIPTION

Heating provided via underfloor heating.



DESIRED EFFECT

Gradual heating effect.
Good cooling on the heating unit.

EXTENT/IMPLEMENTATION

The floor is removed and re-built with underfloor heating pipes and heat distribution plates.

COMMENTS:

HERITAGE AGENCY

Underfloor heating could be a possibility with the creation of new floors.

ENGINEER - STRUCTURAL

The introduction of underfloor heating could be relevant in the basement, but it requires a relatively large excavation depth in order to achieve an acceptable depth of insulation. The excavation depth can cause problems with the stability of the foundations/walls as a result of reduced support from the earth. More information on the foundations must be provided.

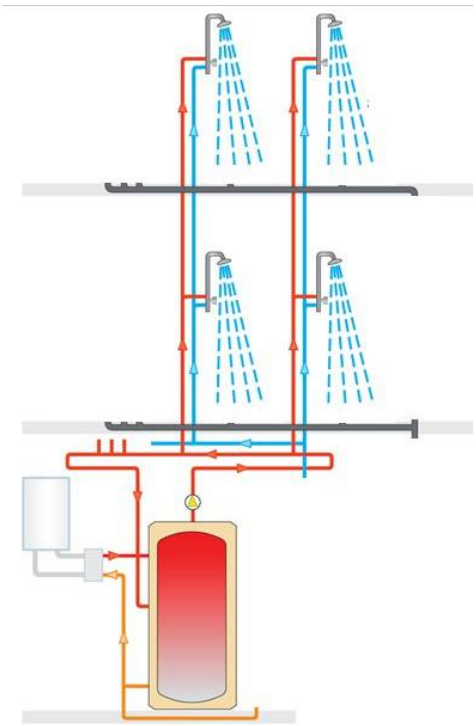
ENGINEER – HVAC (HEATING, VENTILATION AND AIR CONDITIONING)

An underfloor heating solution is not sufficient when there are workstations close to the windows, as the parapets appear to be insulated and the heat loss is larger than that an underfloor heating system can provide with a wooden floor.

INITIAL ASSESSMENT

The initiative is used in the ground floor in buildings 7/8/9 and 11.

NO. 23 DOMESTIC WATER PRODUCTION, CENTRALISED.



DESCRIPTION

Domestic hot water heated in one central place and distributed out to the draw-off points.

DESIRED EFFECT

Potential for solar heating of the water, as well as increased cooling of district heating supply.

EXTENT/IMPLEMENTATION

A hot water tank is placed in a central location in the building and a pipe distribution system serves consumption devices in the building.

COMMENTS:

HERITAGE AGENCY

The feasibility of the initiative is dependant on the size of the plant and service routes required. Potential for solar heating of water – see no. 29.

ENGINEER - HVAC (HEATING, VENTILATION AND AIR CONDITIONING)

A centralised production of hot water allows the use of any solar panels, excess heat from the cooling unit and condensate from the steam plant.

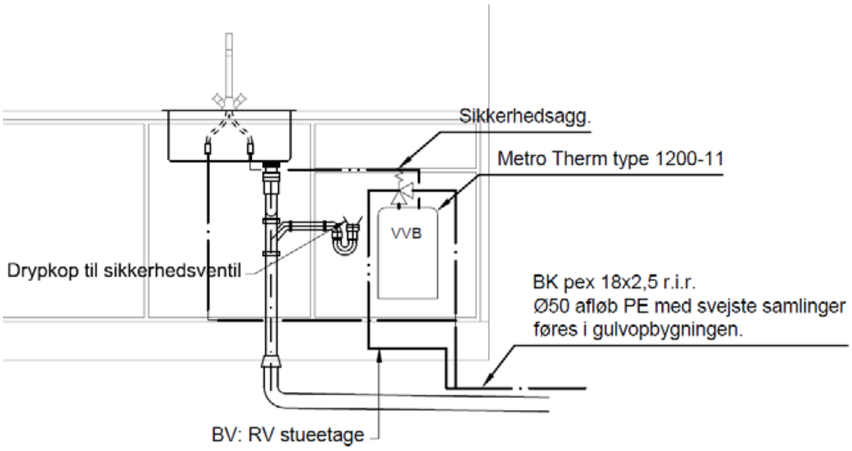
INITIAL ASSESSMENT

Implemented only where there is sufficient water consumption.

No. 24 Domestic water production, de-centralised.

Description

Domestic hot water heated in smaller tanks close to the draw-off points.



Desired Effect

Minimal heat loss from pipe system.

Extent/Implementation

Small hot water tanks are placed where there is a hot water demand. Water is heated via electricity.

Comments:

Heritage Agency

The feasibility of the initiative is dependant on the size of the required components, and the potential for integration of the system into the building.

Engineer - HVAC (Heating, Ventilation and Air Conditioning)

The building only has one shaft with very short pipes down to the central heating plant. A centralised solution is chosen here.
A centralised production of hot water allows the use of any solar panels, excess heat from the cooling unit and condensate from the steam plant.

Initial assessment

The decentralised solution should be used in places where there is only a small hot water consumption.

NO. 25 ENERGY SAVING LIGHT BULBS

DESCRIPTION

Use of alternative light bulbs for permanent lighting.

DESIRED EFFECT

Minimisation of electricity use and wasted energy disposal in the rooms.

COMMENTS:

HERITAGE AGENCY

Approval from the Heritage Agency is not required as light bulbs/-sources are categorised as 'loose fittings'.

ARCHITECT

Subject to the quality and colour of the light.

ENGINEER - HVAC (HEATING, VENTILATION AND AIR CONDITIONING)

A reduction in electricity consumption of around 20 % is expected through using high-efficiency lights.

INITIAL ASSESSMENT

Recommended everywhere.

NO. 26 DAYLIGHT CONTROLLED LIGHTING.

DESCRIPTION

Basic lighting adjusted according to daylight levels.

DESIRED EFFECT

Minimisation of electricity use and wasted energy disposal in the rooms.

COMMENTS:

HERITAGE AGENCY

Approval from the Heritage Agency is not required as the initiative will only affect light sources, which are categorised as 'loose fittings'.

ARCHITECT

Subject to quality and colour of light.

ENGINEER - HVAC (HEATING, VENTILATION AND AIR CONDITIONING)

Daylight controlled lighting is a normal installation in current renovations of office buildings. It ensures an acceptable lighting level, and ensures that the lighting is decreased when there is enough natural light.

INITIAL ASSESSMENT

Recommended everywhere.

NO. 27 CENTRAL CONTROL OF ELECTRICAL COMPONENTS.

DESCRIPTION

Electricity supply to electrical components controlled centrally.

DESIRED EFFECT

Minimisation of standby electricity use by electrical components.

COMMENTS:

HERITAGE AGENCY

The initiative is a possibility, as long as the required infrastructure is acceptable with respect to the architecture of the building.

DEVELOPER

Evident opportunity for savings for tenants. Requirements to the tenant's equipment/routines should be clearly defined.

ENGINEER - HVAC (HEATING, VENTILATION AND AIR CONDITIONING)

Experience suggests that central control of electrical components can result in a reduction in 'out of hours' electricity use from 30% of the total to 10% of the total.

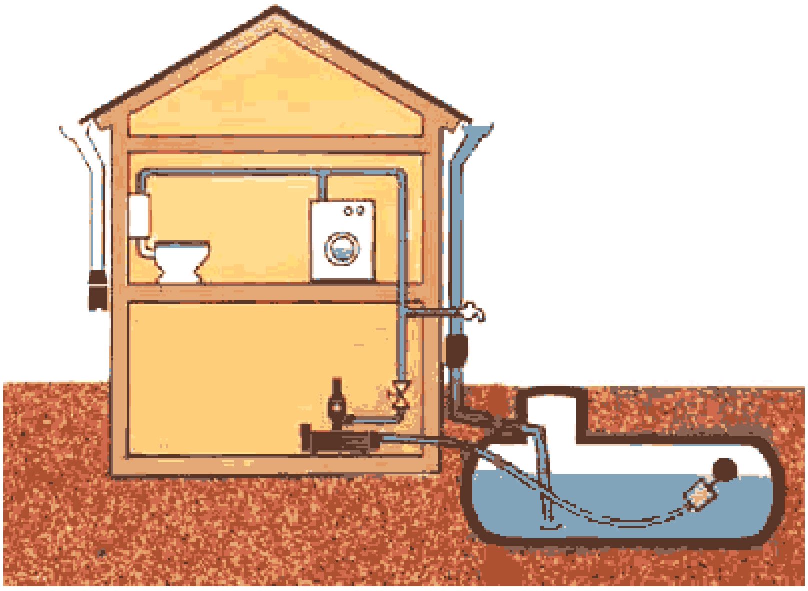
INITIAL ASSESSMENT

Recommended everywhere.

NO. 28 RAIN WATER COLLECTION.

DESCRIPTION

Rainwater collected and used for toilet flushing.



DESIRED EFFECT

Minimisation of water use.

EXTENT/IMPLEMENTATION

Rain water from the roof is collected in a tank for use in toilets and possibly washing machines.

A separate pipe distribution system should be allowed for.

COMMENTS:

HERITAGE AGENCY

The initiative can be considered subject to incorporation of the piping. Rainwater tanks may not mar the listed building or the listed courtyard.

ARCHITECT

The rainwater tank should be under ground where it is not visible and there is no risk for water damage to the buildings.

ENGINEER - HVAC (HEATING, VENTILATION AND AIR CONDITIONING)

Due to the small level of water use in the building the potential savings in operating costs will not match the initial cost of the system.

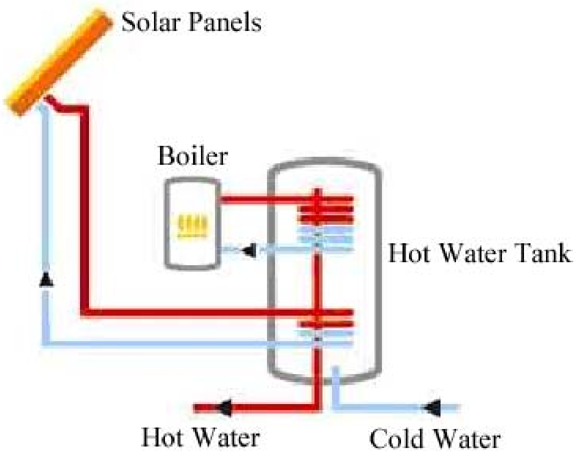
INITIAL ASSESSMENT

Rejected due to the low water consumption.

NO. 29 SOLAR PANELS FOR HOT WATER PRODUCTION.

DESCRIPTION

Solar panels connected to hot water production.



DESIRED EFFECT

Minimisation of heating demand for the heating of domestic water.

EXTENT/IMPLEMENTATION

A solar panel is set up on the roof facing the sun side.
Requires that nr. 23 is carried out.

COMMENTS:

HERITAGE AGENCY

Solar panels are not acceptable on the roof, as they would be an obvious foreign element and mar the experience of the listed building as a whole.

ARCHITECT

Solar cells and solar panels on the roof are foreign compared to the material of the roof and impair the experience of the roof as an architectural whole.

ENGINEER - HVAC (HEATING, VENTILATION AND AIR CONDITIONING)

A low temperature heating system or a larger domestic water consumption are necessary in order to be able to fully exploit solar panels.

INITIAL ASSESSMENT

Rejected as it is not possible to place the panels on the buildings.

NO. 30 SOLAR PANELS FOR HEATING.

DESCRIPTION

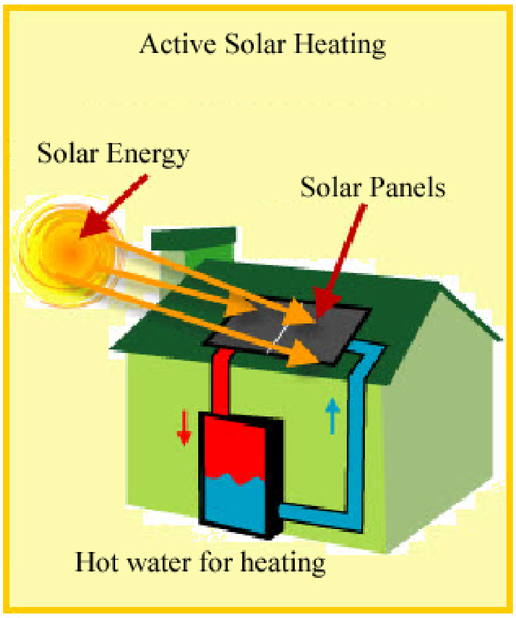
Solar panels connected to heating production.

DESIRED EFFECT

Savings in heating.

EXTENT/IMPLEMENTATION

A solar panel is set up on the roof facing the courtyard.
Requires a buffer tank.



COMMENTS:

HERITAGE AGENCY

Solar panels are not acceptable on the roof, as they would be an obvious foreign element and mar the experience of the listed building as a whole.

ARCHITECT

Solar cells and solar panels on the roof are foreign compared to the material of the roof and impair the experience of the roof as an architectural whole.

ENGINEER - HVAC (HEATING, VENTILATION AND AIR CONDITIONING)

Can not be performed without visible external panels.

INITIAL ASSESSMENT

Rejected as it is not possible to place the panels on the buildings.

NO. 31 PHOTOVOLTAICS.

DESCRIPTION

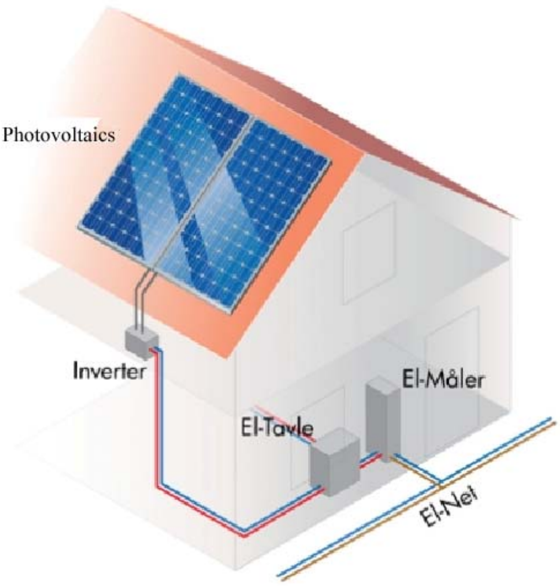
Photovoltaics for production of electricity.

DESIRED EFFECT

Production of electricity.

EXTENT/IMPLEMENTATION

Photovoltaics are placed on the roof, end wall or in the courtyard.



COMMENTS:

HERITAGE AGENCY

Photovoltaics are not acceptable on the roof, masonry or in the courtyard, as they would be an obvious foreign element and mar the experience of the listed building as a whole.

ARCHITECT

If photovoltaics can be integrated into the external lights in a satisfactory way then the external lighting could potentially be powered with help from the photovoltaics.

ENGINEER - HVAC (HEATING, VENTILATION AND AIR CONDITIONING)

Can not be performed without visible external cells/panels.

INITIAL ASSESSMENT

Rejected as it is not possible to place the panels on the buildings.

NO. 32 DECENTRALISED PLACING OF HEAT EMITTING COMPONENTS.

DESCRIPTION

Moving heat emitting appliances from the office space to a common server room.

DESIRED EFFECT

Possibility for optimising cooling and reusing excess heat.

COMMENTS:

HERITAGE AGENCY

The initiative depends on whether a supply route can be established.

INITIAL ASSESSMENT

The initiative depends on what technical requirements the tenant has. The initiative is therefore rejected.

DESIGN CONSIDERATIONS

NO. 33 COMMON CANTEEN.

DESCRIPTION

Combining of the kitchen and canteen facilities.

DESIRED EFFECT

Minimisation of installations, as well as reduced operating costs.

COMMENTS:

ARCHITECT

It makes sense to combine the kitchen and canteen facilities. In this way the amount of supply pipes/ducts in the other buildings can be reduced. Building 11, which is, in terms of it's architecture, best suited to visible supply routes, is chosen. This building is also best prepared for large spaces. This means that creating a common canteen is respecting the varied architecture and spatiality of the building.

ENGINEER - STRUCTURAL

The suggestion can be carried out, as long as the concentrated moisture levels are taken into account with the sizing of the ventilation system and the design of the building components. In this sense building 11, with a half-timbered construction, is the least suitable of the four buildings. A central solution will presumably be more respectful in terms of interference in the existing building components.

ENGINEER - HVAC (HEATING, VENTILATION AND AIR CONDITIONING)

The common canteen is placed in building 11. The room temperature and ventilation operating hours adapted to the actual usage patterns.

INITIAL ASSESSMENT

Implemented as described.

No. 34 Common meeting/conference.

Description

Joining of the meeting and conference facilities.

Desired Effect

Minimisation of plant, as well as reduced operating costs.

Comments:

Architect

As with the canteen it makes sense to combine the meeting facilities. Building 11, which is, in terms of it's architecture, best suited to visible supply routes, is chosen. This building is also best prepared for large spaces – the individual meeting rooms will be placed as light elements in one large room. This means that creating a common canteen and grouping the meeting rooms is respecting the varied architecture and spatiality of the building.

Engineer - Structural

It is a good idea to group this function, as the associated technical installations (pipes/duct runs etc.) that have to fit around the bearing construction can now be expected to be reduced compared to a decentralised solution.

Engineer - HVAC (Heating, Ventilation and Air Conditioning)

The common canteen and meeting room are placed in building 11. The room temperature and ventilation operating hours adapted to the actual usage patterns.

Initial assessment

Implemented as described.

NO. 35 ENTRANCE CONDITIONS, AIR LOCK/STORM PORCH.

DESCRIPTION

Main entrance supplied with an airlock.

DESIRED EFFECT

Minimisation of heat loss from the building.

COMMENTS:

HERITAGE AGENCY

The possibility of setting up an air lock will depend on a concrete assessment of a proposed project. An external air lock can not be accepted, as that would impair the experience of the historic building.

ARCHITECT

Dedicated airlocks cannot be created. The entrance is both storm porch and stairwell. The cold entries could possibly be worked on.

ENGINEER - HVAC (HEATING, VENTILATION AND AIR CONDITIONING)

There is a possibility for minimising unintentional air exchange in the building.

INITIAL ASSESSMENT

Can not be implemented due to heritage/conservation issues.

THE AUTHORITIES

THE BUILDING REGULATIONS

The Building Regulations are obligatory for new and existing buildings. Exceptions can be made for listed buildings, and buildings which are a part of a listed monument, if the regulations are assessed to be incompatible with the heritage values of the building.

THE HERITAGE AGENCY

According to the Listed Buildings Law, in order for a building to be listed it should contain sufficient architectural or historical cultural value of national importance.
It is the Heritage Agency that carries out the listing of buildings. The agency itself investigates if there are buildings which should be listed, with a basic starting point in one theme – a specific building type, a specific architect or similar.
The Heritage Agency is an agency under the Ministry of Culture, which has overall responsibility for the management of Denmark’s cultural heritage. The agency is therefore the authority on listed buildings and conservation, historical relics and archaeology. The Heritage Agency also advises the country’s museums and runs a number of databases within the stated areas.
On the building side the agency manages the law on “building listing and conservation of buildings and city environments”. The agency handles the listing of buildings as well as changes to and repealing of listings. All building work on listed buildings, except ‘normal maintenance’, requires prior approval from the Heritage Agency.

THE DANISH WORKING ENVIRONMENT AUTHORITY

The Danish Working Environment Authority’s rules for the design of working stations are applicable, and therefore the following points with regards to temperature and draughts/cold radiation should be considered.

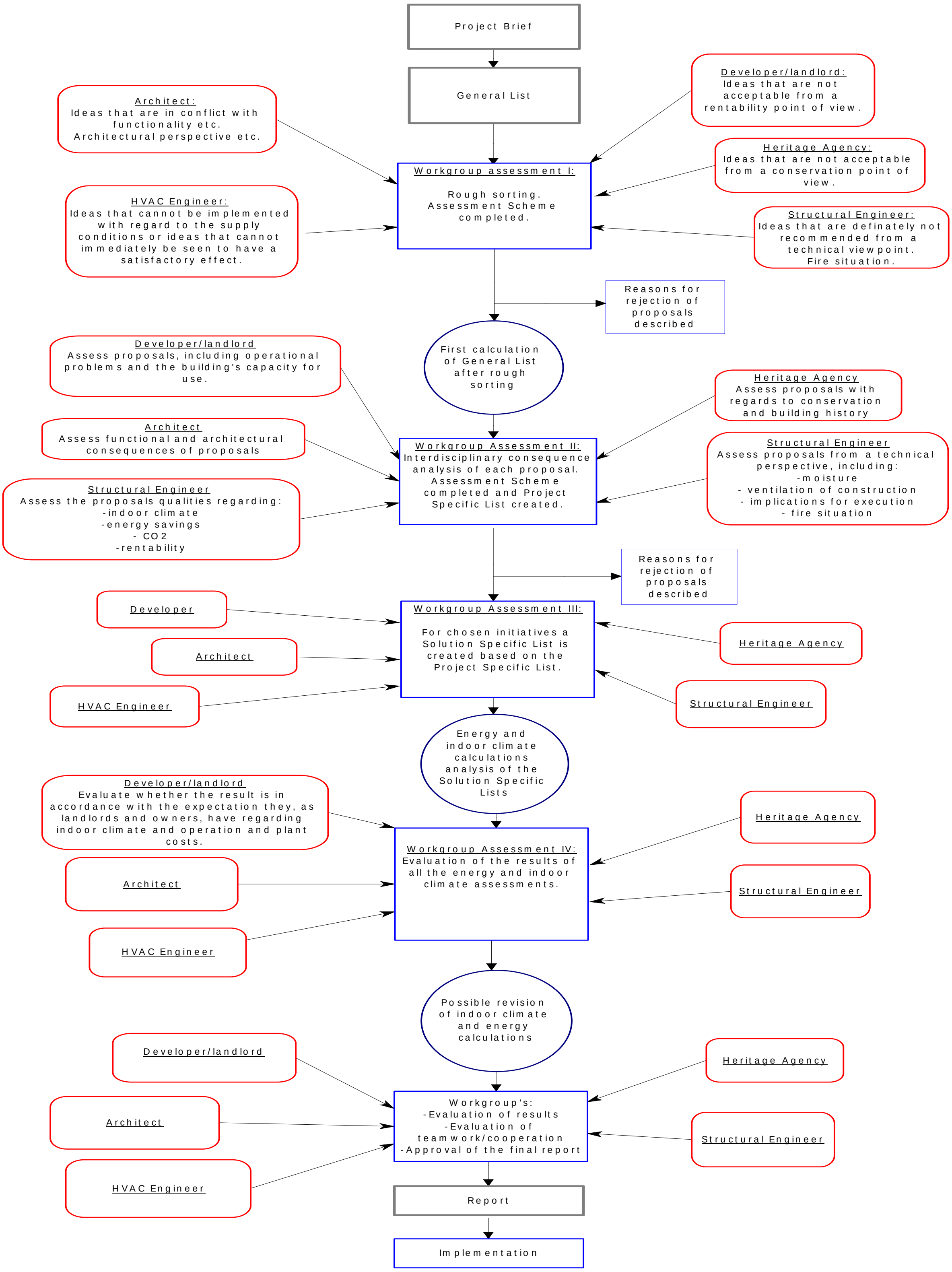
<u>AT-1.2</u>
“A temperature of 20-22 °C is appropriate with lightly physical activities for example in schools, day care and offices. With a temperature of 23 °C or over the number of complaints about indoor climate symptoms increases, and measures should therefore be taken to reduce the temperature. The temperature for sedentary work and normal climate and work conditions may not rise above 25 °C.

In the winter, poorly insulated walls, floors and windows can often create cold areas or cold radiation, which is felt as a draught. Poorly sealed doors and windows often give draught problems, especially when combined with an air extraction system. The air speed in rooms where there are people should be kept under 0,15 m/sec.”

(Example of requirements from the Danish Working Environment Authority)

PROCESS FOR SELECTION OF ENERGY SAVING INITIATIVES

WORKFLOW DIAGRAM



DESCRIPTION OF DIFFERENT TERMS

GENERAL LIST

The General List is a list of all the potential energy saving initiatives which should be considered in connection with the renovation of any building complex. It is based on an older, outdated building complex which is to be converted for modern use, where there is to be performed an energy conscious design. These initiatives, together with the initial assessments/comments are listed in chapter 2: “Proposals for energy saving initiatives”.

ASSESSMENT SCHEME

For each energy saving initiative in the General List there is an Assessment Scheme, where it can be seen why or why not the energy saving initiative was/was not recommended for further development through the process. These Assessment Schemes can be downloaded from www.realdaniabyg.dk.

PROJECT SPECIFIC LIST

The Project Specific List is produced by removing the energy saving initiatives in the General List which are not possible in reality. An initiative can be removed for many reasons, for example because of conservation interests or due to architectural, structural and/or indoor climate issues etc. The Project Specific List can be downloaded from www.realdaniabyg.dk.

ELEMENT CARD

An element card is produced for all the proposed energy saving initiatives that are recommended to the Project Specific List. The element card describes the scope of each energy saving initiative as well as the savings potential, simple pay-back time and finally suggests the expected C02 savings. The Element Card for each energy saving initiative can be downloaded from www.realdaniabyg.dk.

INDOOR CLIMATE LEVEL

In order to distinguish between the different quality levels of indoor climate conditions in primary rooms, as well as being able to describe a desired future level, the code DS/EN ISO 7730 has defined three different indoor climate levels.

- Class A,”Optimal” indoor climate. Describes the sharpest requirements that are considered to be realistic to set for indoor climate.
- Class B, Slightly better indoor climate than the minimum requirement. This class can usually be achieved without much extra expense by thinking of the indoor climate during the design phase of the project.
- Class C, Describes the current requirements in the Building Regulations and guidance from the Working Environment Authority, and therefore acts as a minimum requirement for new buildings and major renovations. The indoor climate is generally perceived to be acceptable.

The classification consists of the following:

Temperature – Air speed - Air quality – Ventilation – Pollutants from building materials – Pollution in general, including particles – Acoustic environment – Lighting conditions.

The temperature conditions, as defined in Class C, are used in this report as the goal for an acceptable thermal environment. The other parameters are expected to be fulfilled to a Class C level. Where natural ventilation (via openable windows) is used, the requirements for air speed and possibly noise from outside cannot be expected to be fulfilled.

WORKFLOW PROCESS

DESIGN BRIEF

The construction brief produced in April 2008 formed the basis for the energy project. The programme included: building history, description of the existing conditions together with an antiquarian/architectural values analysis of the building complex.

GENERAL LIST

Initially a comprehensive list of energy saving initiatives was produced. The list was produced without regard to the architectural and heritage value of the buildings, just as the proposals did not take into account the location, actual building geometry, function or similar, that could immediately mean that the proposals could not be implemented. The General List was created in order to look as widely as possible at all available initiatives, without taking into account the specific conditions of the buildings.

Based on the General List, Assessment Schemes were created for all energy saving proposals for future assessment.

WORKGROUP ASSESSMENT 1

The first workgroup assessment was a rough sorting of the General List. All the project group members conducted their overall assessment. Each General List proposal was thereby subjected to a first interdisciplinary evaluation. Based on this an upgraded General List of proposals suitable for further working was produced.

WORKGROUP ASSESSMENT 2

Before the second workgroup assessment there was, based on the existing consumption readings for water, heating and electricity, produced an estimated model for how the existing consumption, heat loss, hot water production etc. was divided.

At the same time all the buildings were entered into a simulation program for indoor climate/energy. The buildings' separate building components were entered with the existing construction, areas and compass orientation. The simulation model was supplied with the existing people loads and lighting systems. The model gave the opportunity to see the existing energy use divided between the building components, but also to get an idea of the existing thermal environment in different reference rooms spread over the different stories.

Finally element cards were produced for those energy saving proposals from the General list that, based on the first evaluation, were recommended for further development. The element cards outlined each initiative's scope and effect on the future consumption. As mentioned before the element cards are placed in this report as the last side in the relevant assessment scheme.

The result of the second assessment was therefore a more detailed description of how the separate energy saving proposals specifically could be carried out, as well as the impact of the proposal in terms of C02 savings, energy savings and indoor climate effects. The results were entered in the Project Specific list.

WORKGROUP ASSESSMENT 3

The third workgroup assessment was performed based on the results from the second assessment. Each energy saving proposal in the Project Specific list was considered in detail.

The third assessment was conducted in order to make a solution specific selection of energy saving initiatives that together support each other and were reasonable in relation to the requirements for the interior layout.

WORKGROUP ASSESSMENT 4

The fourth workgroup assessment was undertaken to go through and possibly correct the adopted model, in case the initiatives did not together fulfil expectations and lead to the desired effects within C02 saving, energy savings and indoor climate effects.

SELECTION – ASSESSMENT AREAS

HERITAGE AGENCY'S ASSESSMENT:

The initiative evaluated specifically for each building from a conservation/heritage point of view. Wherever possible a more general assessment/opinion of the initiative is also given. These assessments/opinions are only for guidance. The final, official approval can only be given once the entire project is submitted.

ARCHITECT'S ASSESSMENT:

The initiative is evaluated specifically for each building from an architectural point of view. Among others were form, appearance, functionality and interior design evaluated. These evaluations were further supplemented wherever possible with more general assessments and views.

STRUCTURAL ENGINEER'S ASSESSMENT:

The initiative is evaluated specifically for each building from structural design perspective. The impact of the initiative on the existing construction was risk assessed, especially with respect to moisture levels etc. Wherever possible a more general assessment/opinion of the initiative is also given, with references to relevant literature.

DEVELOPER 'S ASSESSMENT:

The initiative is evaluated specifically for each building from an owner's perspective. The impact of each initiative on, among other things, rental opportunities and operation/maintenance conditions were evaluated.

HVAC ENGINEER'S ASSESSMENT:

The initiative is evaluated specifically for each building from an energy and internal climate point of view. The impact of the initiatives in terms of energy saving effect and room temperature were evaluated especially critically. Wherever possible a more general assessment/opinion of the initiative is also given, with references to relevant literature.

FURTHER DEVELOPMENT

If a suggestion required further development, or if a material sample needed be obtained before the initiative can be assessed, it was "Recommended for further development". At this point a comment was written about what documentation is required in order for the initiative to be assessed for a final approval/rejection.

CALCULATION METHODS

BSIM CALCULATION MODEL – METHOD OF ANALYSIS

A calculation model was built up for each building. The calculation models were used for testing of the different initiatives that the working group evaluations recommended for further development.

To ensure trustworthy calculation models the buildings were built up with the existing interior layout and people loads and then compared with the previous five years consumption of water, heating and electricity. The models were created alongside the development of the preliminary design.

CALCULATION STEP 1

The first calculation was built up from the existing conditions and consumption. This calculation formed the basis for calculation steps 2 and 3.

CALCULATION STEP 2

The second calculation was a ‘simplified’ version of calculation step 1. Special usage such as the printing area in building 11, ventilation units in building 7, cooling unit in building 4 together with the heating plant in building 1 were removed. Interior layout and people loads were the same as in calculation step 1.

Most of the energy saving initiatives do not just have one direct impact on energy use, but also have an impact on the room temperature. To ensure that the effect of the energy saving initiatives could be compared with the existing conditions there was, in the existing conditions calculation, entered a fictitious cooling. The level was maintained at a “C-level”, as that is the lowest acceptable level according to DS 1752. The room temperature is maintained over 20 degrees in the winter and over 24,5 degrees (plus/minus 2,5 degrees) in the summer. The net effect for each energy saving initiative is therefore calculated from the direct saving minus the extra energy costs for cooling. The lighting is also chosen to be daylight controlled. With a daylight controlled system a potential increase in the level of natural light can be offset by a reduced lighting requirement.

The calculation model was the base model for the calculation of all the energy savings initiatives from the General list which were to be valued before the preliminary design was finally determined.

CALCULATION STEP 3

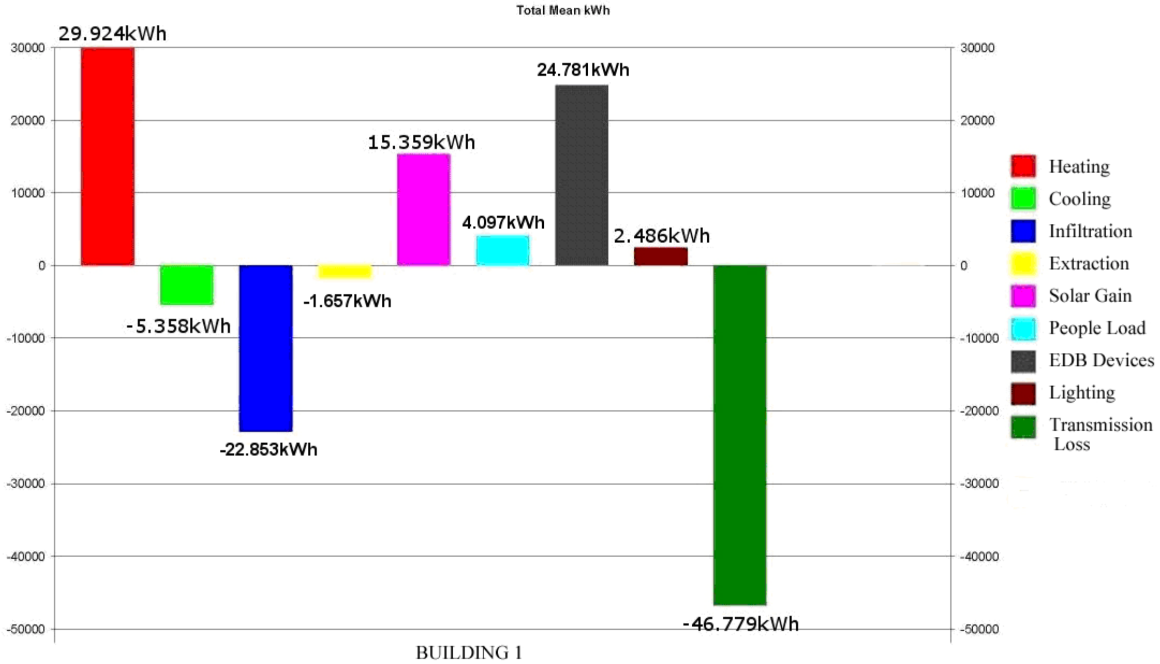
The third calculation was carried out alongside the preliminary design. Interior layout, windows opening and an increased people load were implemented in this model. Each energy saving initiative was recalculated and the results presented in the Project Specific list. This calculation model is also the reference model for the combined solutions, where multiple energy saving initiatives are joined in one calculation.

PRESENTATION OF RESULTS

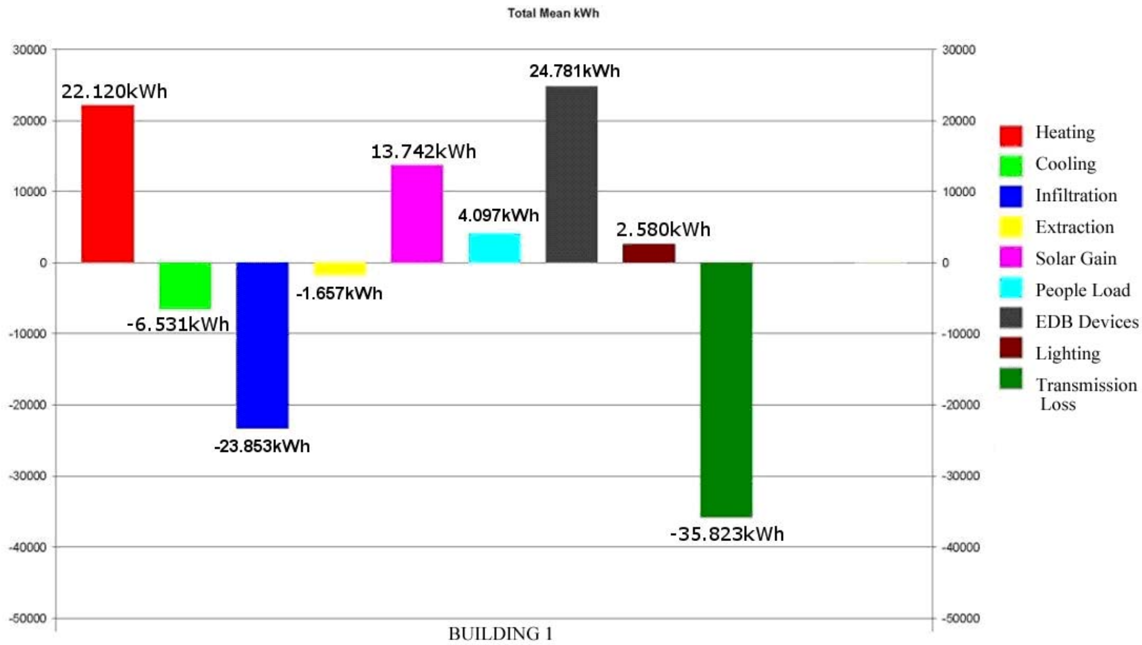
The results of the calculations for each of the energy saving initiatives were moved to the relevant initiative’s element card. The most relevant data was also presented in a table in the Project Specific list. The calculations are based on the simulated interior climate and heat balance.

CALCULATION OF IMPACT ON CONSUMPTION

The example below shows the Supervisor's Dwelling when energy initiative 2a, new energy saving secondary glazing in the existing frames, is implemented.



The graph above shows reference heat balance in the Supervisor's Dwelling. The heat balance is based on the future interior layout with the future people loads, where the temperature is kept at a Class C level via cooling.



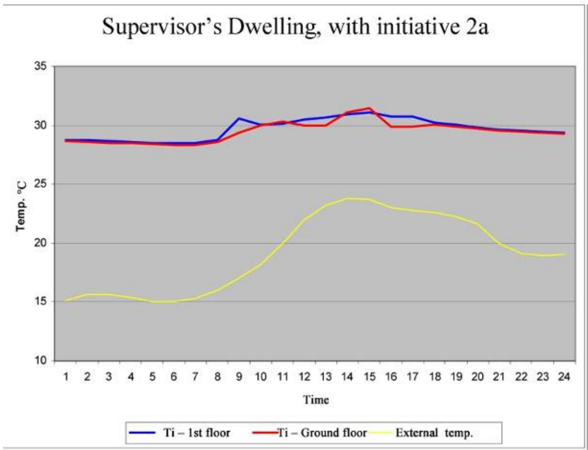
The graph above shows a breakdown of the energy use in the Supervisor's Dwelling, where the existing secondary glazing is changed to energy saving glazing. The thermal internal climate is maintained via cooling at the same level as the above reference building.

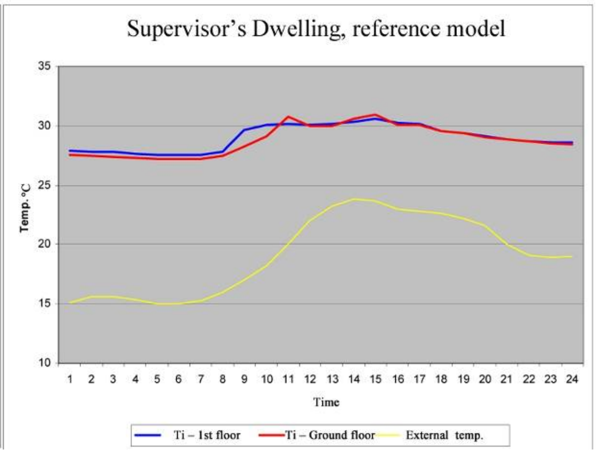
The two graphs above were converted to a table in order to enable comparison. In the table the change in energy use between the two graphs was shown as a percentage and the change in C02 was calculated.

CALCULATION OF THE IMPACT ON THE INTERNAL CLIMATE

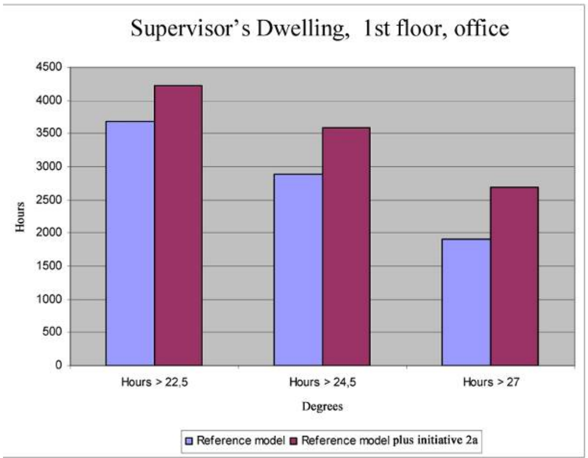
In order to find the impact on the internal climate that occurs due to the implementation of an energy saving initiative a calculation was carried out using a reference calculation model, where the room temperature was not controlled by a fictitious cooling, ventilation or increased lighting due to less daylight.

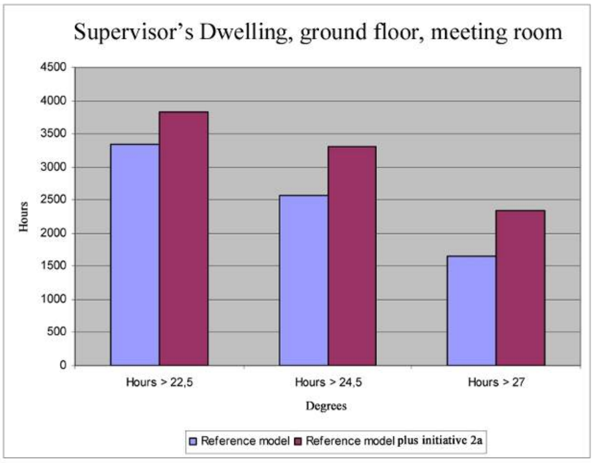
The examples below show the thermal internal climate in the Supervisor's Dwelling when energy initiative 2a, new energy saving secondary glazing in the existing frames, is implemented.





The graph to the right shows the thermal internal climate in the Supervisor's Dwelling on a summers day.
The graph to the left shows the thermal internal climate on the same day with initiative 2a included in the calculation.



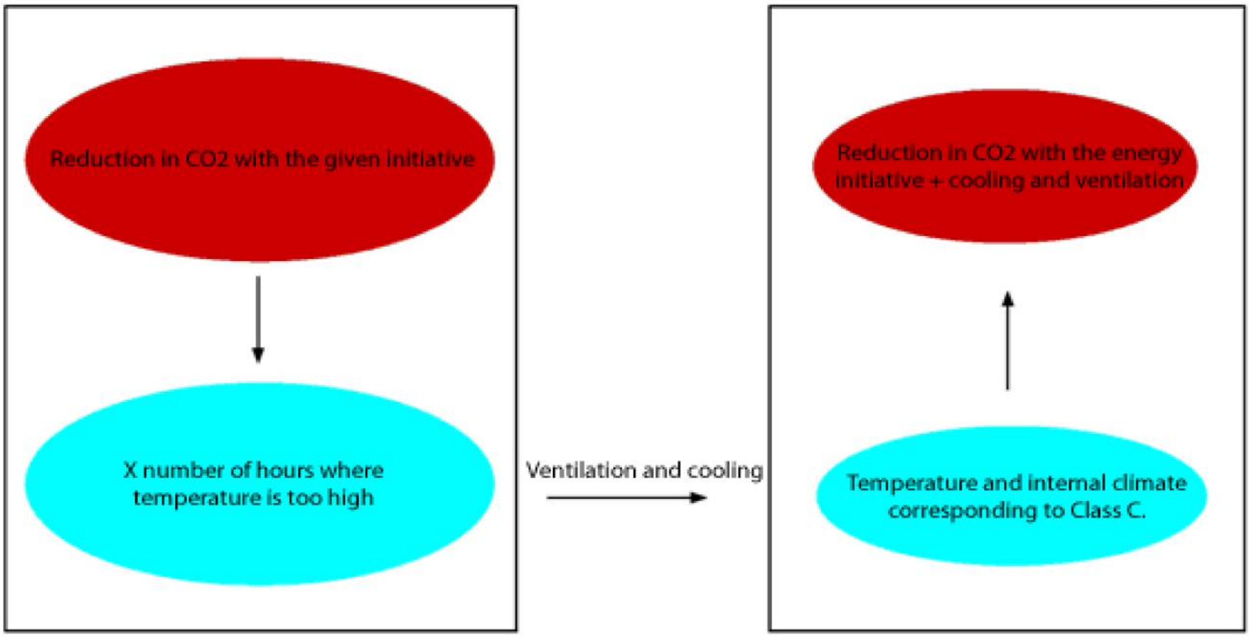


The graphs above show the number of hours where the temperature is over a specified temperature in, respectively, the first floor office and the ground floor meeting room.

The above graphs were converted to a table in order to enable comparison. The number of hours where the temperature was above the specified temperature was calculated as shown on the following page.

Energy Saving Initiative

Energy Saving Initiative, Ventilation and Cooling



The energy saving initiative results in an increase in the number of hours where the temperature is above a certain level. This results in an internal climate which is worse than that recommended by the Working Environment Authority, Class C.

In order for the internal climate to achieve a Class C level the building has to be ventilated and cooled. The overall reduction in CO2 is therefore reduced, but an acceptable internal climate is achieved.

The diagram above is exemplified by the calculations below. The example is from building 1, where the effect of replacing all secondary glazing with energy efficient glass is calculated.

Energy Saving Initiative

Consumption	MWh/Ton	KWh/Kg pr. m2	
CO2	**18,22**	**34,38**	**5,71%**
Trans. Loss	-39,28	-74,1	21,71%
Heating	22,06	41,6	26,07%
Elec. - Devices	24,78	46,8	0,00%
Elec. - Lights	2,49	4,7	-2,42%
Cooling	0,00	0,0	0,00%
Int. Climate Consequence		**New (hours)**	**Existing**
Ground meeting	24.5<	3306	2568
Ground meeting	27<	2343	1658
Ground office 2	24.5<	3579	2892
Ground office 2	27<	2691	1913
First floor office 1	24.5<	3357	2787
First floor office 1	27<	2467	1845
First floor office 2	24.5<	3366	2889
First floor office 2	27<	2449	1868

Energy Saving Initiative, Ventilation and Cooling

Consumption	MWh/Ton	KWh/Kg pr. m2	
CO2	**19,48**	**36,75**	**4,29%**
Trans. Loss	-35,82	-67,6	23,42%
Heating	22,12	41,7	26,08%
Elec. - Device	24,78	46,8	0,00%
Elec. - Lights	2,58	4,9	-3,75%
Cooling	-6,53	-12,3	-21,88%
Int. Climate Consequence		**New (hours)**	**Existing**
Ground meeting	24.5<	606,0	320
Ground meeting	27<	11	2
Ground office 2	24.5<	926,0	560
Ground office 2	27<	71	46
First floor office 1	24.5<	940	595
First floor office 1	27<	33	20
First floor office 2	24.5<	495	366
First floor office 2	27<	9	5

The calculation scheme below was created based on these calculations. The top part of the scheme shows how much CO2 can be saved for the given initiative, including ventilation and cooling. The bottom part shows for how many hours the temperature will be too high when the initiative is working alone.

Consumption	MWh/Ton	KWh/Kg pr. m2	
CO2	**19,48**	**36,75**	**4,29%**
Trans. Loss	-35,82	-67,6	23,42%
Heating	22,12	41,7	26,08%
Elec. - Device	24,78	46,8	0,00%
Elec. - Lights	2,58	4,9	-3,75%
Cooling	-6,53	-12,3	-21,88%

Int. Climate Consequence		New (hours)	Existing
Ground meeting	24.5<	3306	2568
Ground meeting	27<	2343	1658
Ground office 2	24.5<	3579	2892
Ground office 2	27<	2691	1913
First floor office 1	24.5<	3357	2787
First floor office 1	27<	2467	1845
First floor office 2	24.5<	3366	2889
First floor office 2	27<	2449	1868

PROCESSING OF RESULTS

In the example on the previous page the consequence of implementing new energy saving secondary glazing to reduce heat loss can be seen. On the plus side there can be seen a reduction in heat loss of 26,08 %. On the other hand there can be seen an increase in energy use of 3,75 % for lighting, due to the new glass having lower light penetration. When the buildings insulation is improved, the room temperature in the building will increase and therefore the cooling load increased by 21,88 %. The overall expected net-CO_2 saving will be 4,29 %. Under the impact on internal climate it can be seen how many hours the temperature raises above 24,4 degrees. The number of hours increases from 2568 hours to 3306 hours.

CO_2-consumption was calculated via the yearly calculated energy use compared with the current energy suppliers' CO_2-accounts.
Copenhagen Energy supplies district heating in the form of steam, whereby 1 ton CO_2 equates to 6,8 MWh. Dong Energy supplies electricity, where 1 ton CO_2 equates to 1,9 MWh.
The above values are from 2007.
Where cooling is used the COP factor was set to 3 (the COP factor gives the relationship between the native energy and the cooling effect derived from it).

SELECTION OF ENERGY SAVING INITIATIVES.

GENERAL SOLUTIONS

Electricity based energy savings in the office environment should be highly weighted in the decision making process, as these give both direct CO_2 savings and derived savings as a result of a reduced cooling load in the summer season. For example reductions can be achieved through a central shut-off of power outside of working hours which ensures that all IT devices, lights etc. are turned off. In terms of the planning and layout there can be achieved savings by moving electrical devices which give off heat away from the office environment and to a common “technical room”.

The following initiatives are therefore implemented in all the buildings:

25. Energy saving light bulbs
26. Daylight controlled lighting
27. Central control of electrical components

The planning and layout initiatives are not calculated.

33. Common canteen
34. Common meeting and conference facilities.

BUILDING 1 – SUPERVISOR'S DWELLING

WORKGROUP ASSESSMENT 1

The great respect for the core heritage values of the building was already clear at the first workgroup assessment, where suggestions for new energy saving windows, external and internal solar shading, internal and external post-insulation were rejected, along with a long list of other energy saving initiatives.

The majority of the energy saving solutions for the electrical and services installations (replacing of glass in the secondary glazing, increasing the tightness of the building envelope and post-insulation of the sloping walls in the loft room) were however recommended for further development.

WORKGROUP ASSESSMENT 2

At the second workgroup assessment solutions for, among others, ventilation were presented. It was decided that any form of mechanical ventilation must be avoided, even though it could clearly be seen that there was a need for temperature reduction in the rooms, even with a relatively low outside temperature. It was agreed that the HVAC (Heating, Ventilation and Air Conditioning) engineers would find examples of combined heating/cooling units for the group's next assessment, in order to see if the unacceptable internal climate situation could be solved in that way.
Other proposals were again recommended for further development.

WORKGROUP ASSESSMENT 3

Through the third workgroup assessment the combined heating/cooling unit solution was found to be acceptable, although there was a requirement that the housing should be adapted so that it looked like a flat panel radiator.
The workgroup agreed that the following initiatives should be used to create the solution to be calculated:

2a. Energy saving glass – 3mm glass set into the existing secondary glazing frames
10. Building envelope air permeability: 0,5 h^{-1} basement
0,2 h^{-1} ground floor
0,2 h^{-1} first floor
11. Ventilation via opening of windows
16. Cooling. Specially designed unit
18. Cooling via a centrally placed unit where excess heat is transferred to the outside air
23. Centralised domestic water production
25. Energy saving light sources
26. Daylight controlled lighting
27. Centralised control of electrical components
33. Shared canteen
34. Shared meeting and conference facilities

The point numbers correspond to the points in chapter 2.

It should be mentioned that point 2a. (energy saving glass) results in an expected CO2 reduction of 4,29%, point 10 (envelope permeability) in a reduction of 6,11% and point 27 (centralised control of electrical components) a reduction of not less than 7,50%. On the other hand the necessary increase in cooling is expected to have a negative effect on the projected CO2 savings of 0,47%.

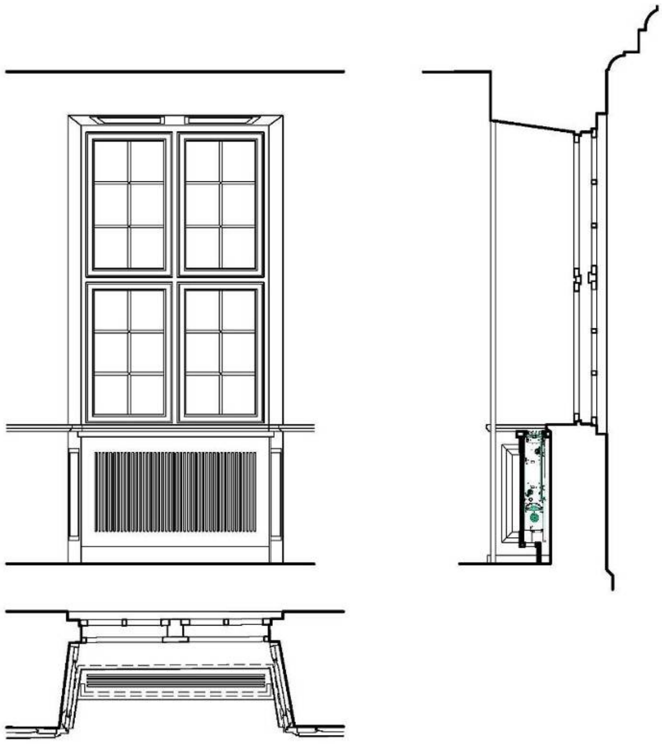
WORKGROUP ASSESSMENT 4

Through the fourth workgroup assessment the results of the calculations were carefully reviewed. The workgroup assessed that the overall result can be expected to give a reduction in transmission loss of 27% and an overall CO2 reduction of 20%. Compared to the existing building the expected CO2 reduction is 6%.
It is also expected that it is possible to achieve a thermal internal climate level in class C.
All in all a much more positive result than the group had expected.

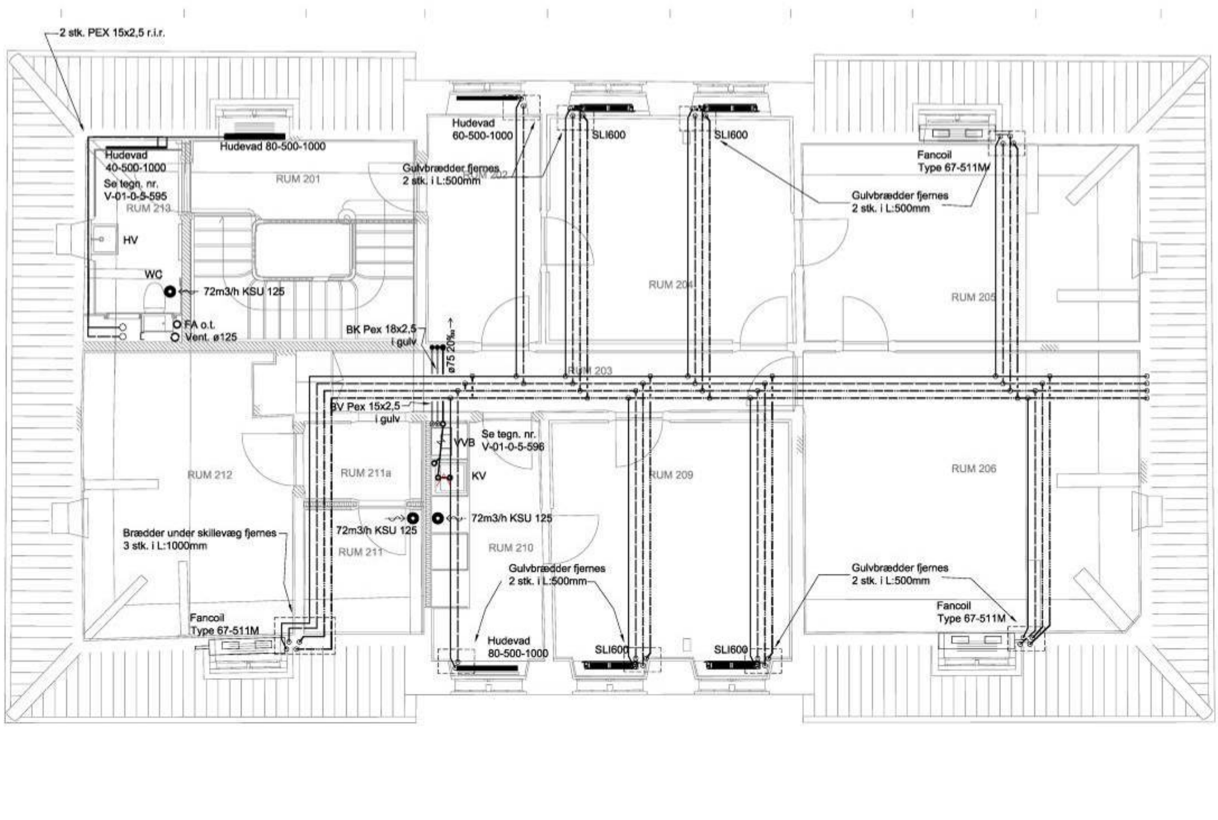
Pt. no. Original usage:	**Heating/m2 56,5w/m2**	**Cooling/m2 -10,1w/m2**	**Electricity/m2 51w/m2**	**CO2 - savings**
2a	41,7	-12,3	51,7	4,29%
10	37,6	12,2	51	6,11%
11	-	-	-	-
16	-	-	-	-
18	-	-	-	-
23	-	-	-	-
25	57	-5,24	50	1,25%
26	-	-	-	-
27	59,4	-8,7	45,9	7,5%
Total	**35,2**	**-10,9**	**42,8**	**20,06%**

”-” These initiatives are included in the reference model, so there is no single calculation which shows the specific energy savings for that particular initiative.

Special solution for fancoil initiative – First floor Building 1



The traditional heat risers were replaced with a hidden supply in the floor. This was only possible as the floor was already being replaced.



OVERVIEW OF REJECTED AND APPROVED ENERGY SAVING INITIATIVES

Building 1

Nr.	Energy saving initiative	A1	A2	A3	A4	Reason for rejection of idea
Windows and solar shading						
01a	Replacement of windows with new super low energy windows					Listed status and architecture not respected
01b	New super low energy windows in new window holes					Listed status and architecture not respected
02	New low energy secondary glazing & solar shaded external glazing					External glass can not be replaced due to architecture and listed status considerations
02a	New low energy glass in existing secondary glazing frames					
02b	New solar shaded secondary glazing					Colour of the glass is too marked
03	New windows with internal solar shading					Listed status and architecture not respected
04	External solar shading					Listed status and architecture not respected
Insulation and building envelope permeability						
05	Internal post/insulation of external walls					Initiative does not have a large enough effect
06	External post-insulation of external walls					Listed status and architecture not respected
07	Post-insulation of sloped ceilings					Initiative does not have a large enough effect
08	Post-insulation of ground slab					As the basement is not used the effect is not large enough
09	Use of 'superthin' insulation type					The quality of this type of insulation is unreliable and the effect is not large enough
10	Establishment of tightness in the building envelope					
Ventilation						
11	Natural ventilation - opening of windows					
12	Night cooling, ventilation - intake in building envelope and exhaust in the roof					Fresh air intake through the building envelope not possible
13	Hybrid ventilation, intake in the building envelope and extraction via heat pumps					Fresh air intake through the building envelope not possible
14	Traditional mechanical ventilation via ventilation system					Listed status and architecture not respected
15	Fresh air intake via solar walls, active glass panels					Listed status and architecture not respected
Heating, water and cooling						
16	Cooling via mechanical recirculation of air in the room					
17	Passive cooling of the room via chilled ceiling or walls					Listed status and architecture not respected
18	Cooling where excess heat is transferred to the exhaust air					A central plant is built that supplies all the buildings
19	Cooling via earth pipes					Cooling load is not sufficient
20	Cooling via heat pumps to ground/sea water					Cooling load is not sufficient
21	Heating via radiators					Radiators placed only in rooms where there is no cooling load
22	Under floor heating					New floor construction not possible
23	Centralised domestic hot water production					
24	Decentralised domestic hot water production					Not viable
28	Rainwater harvesting					Limited water use
Electricity						
25	Energy saving light sources					
26	Daylight controlled lighting					
27	Centralised control of electrical components					
Solar panels and solar cells						
29	Solar panels for production of hot water					Listed status and architecture not respected
30	Solar panels for heating					Listed status and architecture not respected
31	Solar cells					Listed status and architecture not respected
Behavioiur and layout						
32	Moving heat producing elements from the office to a shared server room					Requires that the occupants' equipment and routines are more precisely defined
33	Shared cantine					
34	Shared meeting and conference facilities					
35	Storm porch in the main entrance					Listed status and architecture not respected

BUILDING 4 – OFFICE BUILDING TOWARDS BYGHUSGADE

WORKGROUP ASSESSMENT 1

The great respect for the core heritage values of the building was already clear at the first workgroup assessment, where suggestions for new energy saving windows, external and internal solar shading, internal and external post-insulation were rejected along with a long list of other energy saving initiatives.

The majority of the energy saving solutions for the electrical and services installations (replacing of glass in the secondary glazing, increasing the tightness of the building and post-insulation of the sloping walls in the loft room) were however recommended for further development.

WORKGROUP ASSESSMENT 2

At the second workgroup assessment solutions for, among others, ventilation were presented. It was decided that, in general, mechanical ventilation should be avoided,. However there could be created a minimal ventilation solution through the existing chimney. It was clear however that this was not enough to avoid a significantly high temperature in the rooms, even with a relatively low outside temperature. It was agreed that the HVAC engineers would find examples of combined heating/cooling units for the group's next assessment in order to see if the unacceptable internal climate situation could be solved in that way.
Other proposals were again recommended for further development.

WORKGROUP ASSESSMENT 3

Through the third workgroup assessment the solution with a combined heating/cooling unit was found to be acceptable, although there was a requirement that the housing should be adapted so that it looked like a flat panel radiator.
The workgroup agreed that the following initiatives should be used to create the solution to be calculated:

2a. Energy saving glass – 3mm glass set into the existing secondary glazing frames
10. Building envelope air permeability: 0,29 h^{-1} ground floor
0,20 h^{-1} first floor
0,20 h^{-1} second floor
11. Ventilation via opening of windows
16. Cooling. Specially designed unit
18. Cooling via a centrally placed unit where excess heat is transferred to the outside air
24. Decentralised domestic water production
25. Energy saving light sources
26. Daylight controlled lighting
27. Centralised control of electrical components
33. Shared canteen
34. Shared meeting and conference facilities

The point numbers correspond to the points in chapter 2.

It should be mentioned that point 2a. (energy saving glass) results in an expected CO2 reduction of 4,24% and point 27 (centralised control of electrical components) a reduction of not less than 10,75%. The high savings are due to the relatively high number of workstations in the building. On the other hand the necessary cooling and ventilation systems are expected to have a negative effect on the projected CO2 savings of 2,67%.

WORKGROUP ASSESSMENT 4

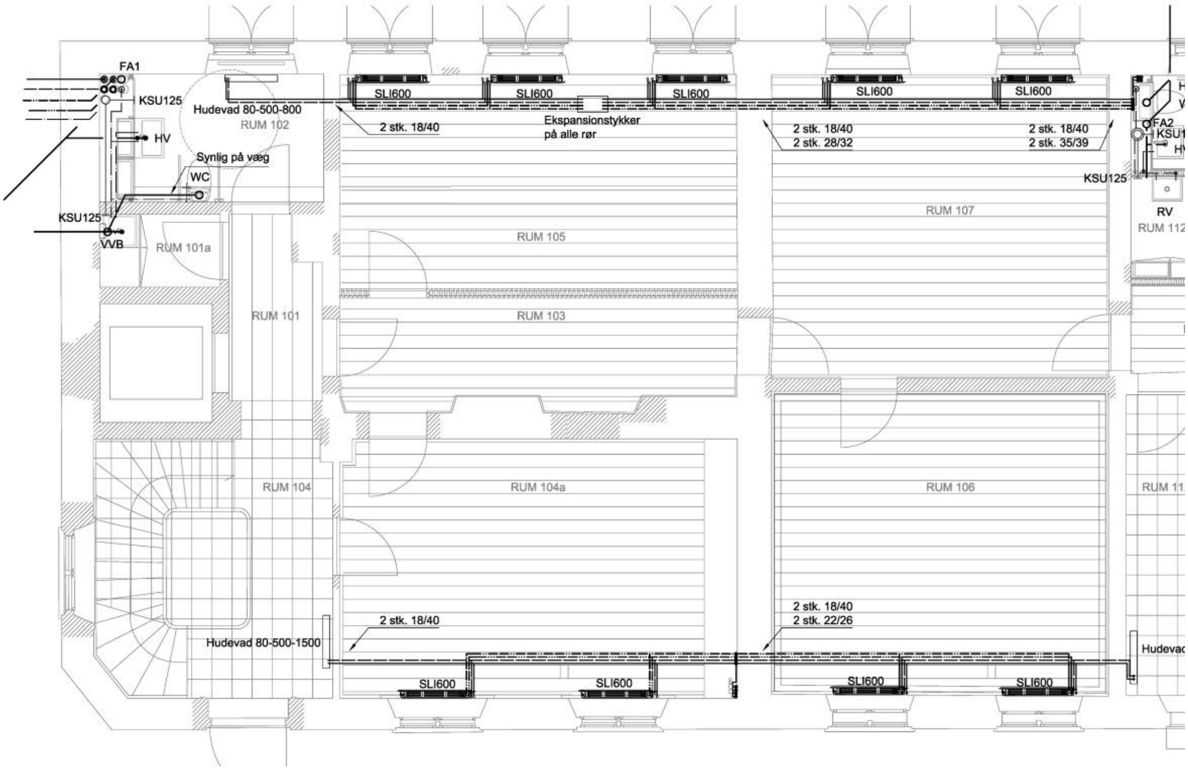
Through the fourth workgroup assessment the results of the calculations were carefully reviewed. The workgroup assessed that the overall result can be expected to give a reduction in transmission loss of 19,6% and an overall CO2 reduction of almost 24%. Compared to the existing building the expected CO2 reduction is 20%.
It is also possible to achieve a thermal internal climate level in class C.
All in all a satisfactory result given that it is necessary to add a substantial cooling capacity as the population density in this building is much higher than in the other buildings. This has a negative effect when one looks at CO2 savings.

Pt. no. Original usage:	**Heating/m2 133w/m2**	**Cooling/m2 -23,9w/m2**	**Electricity/m2 108,8w/m2**	**CO2 - savings**
2a	102,4	-27,3	109,1	4,14%
10	117,9	-26,9	108,8	6,11%
11	-	-	-	-
16	-	-	-	-
18	-	-	-	-
24	-	-	-	-
25	134	-23,3	106,4	1,47%
26	-	-	-	-
27	143,3	-19,9	91,1	10,75%
Total	**120,7**	**-16,7**	**77,6**	**20,57%**

”-” These initiatives are included in the reference model, so there is no single calculation which shows the specific energy savings for that particular initiative.

SPECIAL INTEGRATED SOLUTION FOR FANCOIL INITIATIVE

Supply routes for heating, cooling and electricity are placed in the floor under a removable floorboard.



OVERVIEW OF REJECTED AND APPROVED ENERGY SAVING INITIATIVES

Building 4

Nr.	Energy saving initiative	A1	A2	A3	A4	Reason for rejection of idea
	Windows and solar shading					
01a	Replacement of windows with new super low energy windows					Listed status and architecture not respected
01b	New super low energy windows in new window holes					Listed status and architecture not respected
02	New low energy secondary glazing & solar shaded external glazing					External glass can not be replaced due to architecture and listed status considerations
02a	New low energy glass in existing secondary glazing frames					
02b	New solar shaded secondary glazing					Colour of the glass is too marked
03	New windows with internal solar shading					Listed status and architecture not respected
04	External solar shading					Listed status and architecture not respected
	Insulation and building envelope permeability					
05	Internal post/insulation of external walls					Initiative does not have a large enough effect
06	External post-insulation of external walls					Listed status and architecture not respected
07	Post-insulation of sloped ceilings					Initiative does not have a large enough effect
08	Post-insulation of ground slab					Ikke CO2 rentabel
09	Use of 'superthin' insulation type					The quality of this type of insulation is unreliable and the effect is not large enough
10	Establishment of tightness in the building envelope					
	Ventilation					
11	Natural ventilation - opening of windows					
12	Night cooling, ventilation - intake in building envelope and exhuast in the roof					Fresh air intake through the building envelope not possible
13	Hybrid ventilation, intake in the building envelope and extraction via heat pumps					Fresh air intake through the building envelope not possible
14	Traditional mechanical ventilation via ventilation system					Initiave rejected due to economic reasons
15	Fresh air intake via solar walls, active glass panels					Listed status and architecture not respected
	Heating, water and cooling					
16	Cooling via mechanical recirculation of air in the room					
17	Passive cooling of the room via chilled ceiling or walls					Listed status and architecture not respected
18	Cooling where excess heat is transferred to the exhaust air					A central plant is built that supplies all the buildings
19	Cooling via earth pipes					Cooling load is not sufficient
20	Cooling via heat pumps to ground/sea water					Cooling load is not sufficient
21	Heating via radiators					Radiators placed only in rooms where there is no cooling load
22	Under floor heating					New floor construction not possible in the ground floor
23	Centralised domestic hot water production					Not viable in terms of CO2
24	Decentralised domestic hot water production					
28	Rainwater harvesting					Limited water use
	Electricity					
25	Energy saving light sources					
26	Daylight controlled lighting					
27	Centralised control of electrical components					
	Solar panels and solar cells					
29	Solar panels for production of hot water					Listed status and architecture not respected
30	Solar panels for heating					Listed status and architecture not respected
31	Solar cells					Listed status and architecture not respected
	Behavioiur and layout					
32	Moving heat producing elements from the office to a shared server room					
33	Shared cantine					
34	Shared meeting and conference facilities					
35	Storm porch in the main entrance					Listed status and architecture not respected

BUILDING 7, 8 AND 9 – MONOPITCH ROOF HOUSES

WORKGROUP ASSESSMENT 1

Due to the relatively few core heritage values in these buildings there was open opportunity for a lot of the energy saving initiatives from the General List in the first workgroup assessment. However external post-insulation could naturally not be accepted, as well as internal post-insulation of the external walls towards the courtyard. The majority of the energy saving solutions for the electrical and services installations were recommended for further development.

WORKGROUP ASSESSMENT 2

At the second workgroup assessment, the possibility of creating balanced ventilation with cooling was presented. This would be placed along the backwater during the construction of that. This solution was approved for further development. All the other proposals were also recommended for further development.

WORKGROUP ASSESSMENT 3

As part of the third workgroup assessment all the initiatives were again approved for further working, however a number of choices were made concerning solar shading.

The workgroup agreed that the following initiatives should be used to create the solution to be calculated:

1a. Replacing windows with new super low energy windows
1b. New super low energy windows in new window holes
2a. Energy saving glass in the existing secondary glazing frames (building 8 only)
04. External solar shading – reduction factor ground (building 7 & 9 only) and first floor - 0,5
05. Internal post-insulation of external walls in some areas
08. Post-insulation of the ground slab
10. Building envelope air permeability: 0,35 h^{-1} ground floor
0,17 h^{-1} first floor
14. Balanced ventilation – base exchange rate around 12 l/s person (incl. cooling)
18. Cooling via a centrally placed unit where excess heat is transferred to the outside air
21. Radiator heating – first floor
22. Under floor heating – ground floor
24. Decentralised domestic water production
25. Energy saving light sources
26. Daylight controlled lighting
27. Centralised control of electrical components
33. Shared canteen
34. Shared meeting and conference facilities

The point numbers correspond to the points in chapter 2.

It should be mentioned that point 4 (external solar shading) results in an expected CO2 reduction of 7,25%, point 2a (energy glass) a reduction of 8,13%, point 05 (internal post/insulation) 13,49 %, point 10 (building envelope) 6,77 % and point 27 (centralised control) a reduction in CO_2 of 3,72 %. On the other hand the necessary cooling and ventilation systems are expected to have a negative effect on the projected CO_2 savings of 10,5%.

WORKGROUP ASSESSMENT 4

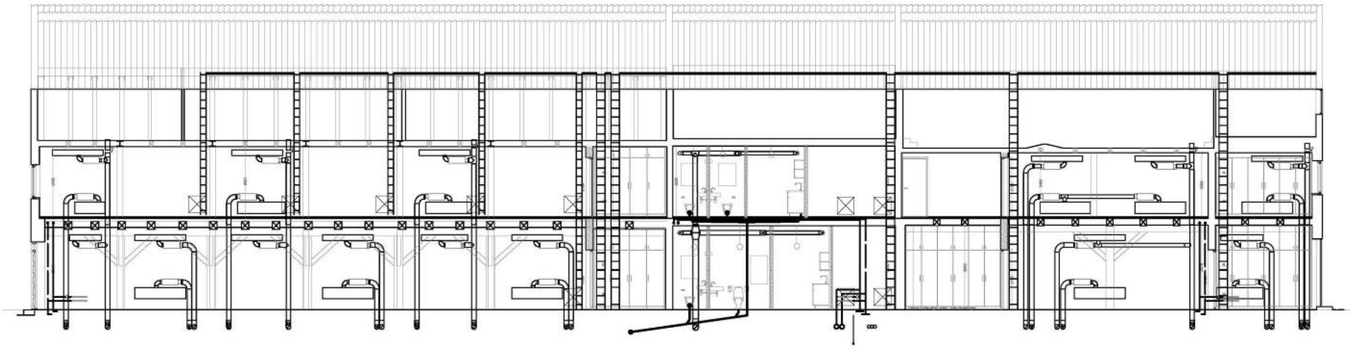
Through the fourth workgroup assessment the results of the calculations were carefully reviewed. The workgroup assessed that the overall result can be expected to give a reduction in transmission loss of 39% and an overall CO_2 reduction of almost 17%. Compared to the existing building the expected CO_2 reduction is 20%.
It is also possible to achieve a thermal internal climate level in class C.
All in all a satisfactory result, roughly the same as the group had expected.

Pt. no. Original usage:	**Heating/m2 111,4w/m2**	**Cooling/m2 -13,9w/m2**	**Electricity/m2 37,4w/m2**	**CO2 - savings**
1b	94,8	5,7	37,4	7,25%
2a	88	-14,5	37,6	8,13%
04	-	-	-	-
05	71,9	16,4	37,4	13,49%
08	91,3	-18,6	37,4	5,26%
10	90,6	15,9	37,4	6,77%
14	110,4	-12,1	41,6	-4,61%
18	-	-	-	-
21	-	-	-	-
22	-	-	-	-
24	-	-	-	-
25	62,53	13,9	36,6	0,86%
26	-	-	-	-
27	116,7	13,1	33,6	3,72%
Total	**55**	**12**	**41,1**	**16,61%**

”-” These initiatives are included in the reference model, so there is no single calculation which shows the specific energy savings for that particular initiative.

INSTALLATION WALL

The back wall of the building is covered by an installation wall. The wall also works as a form of post-insulation of the building.



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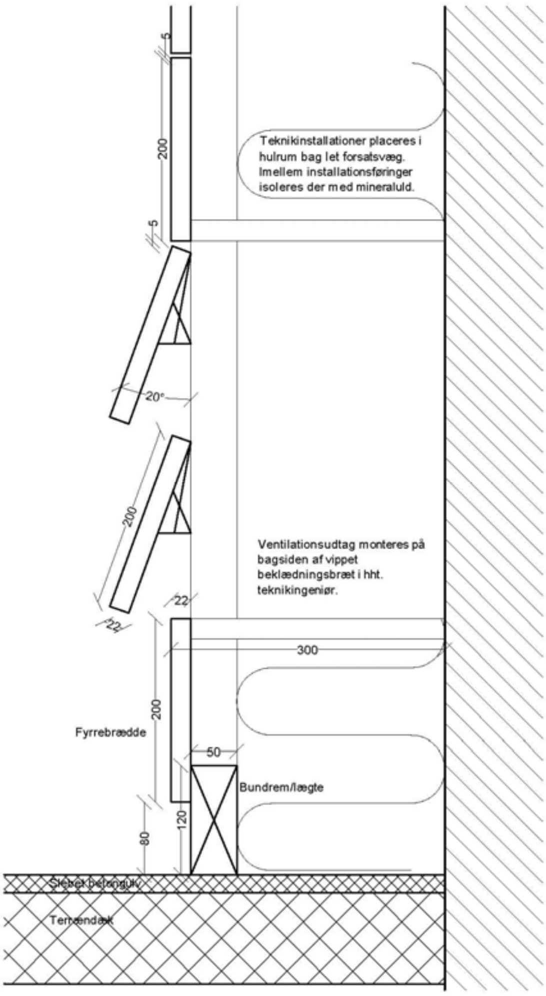
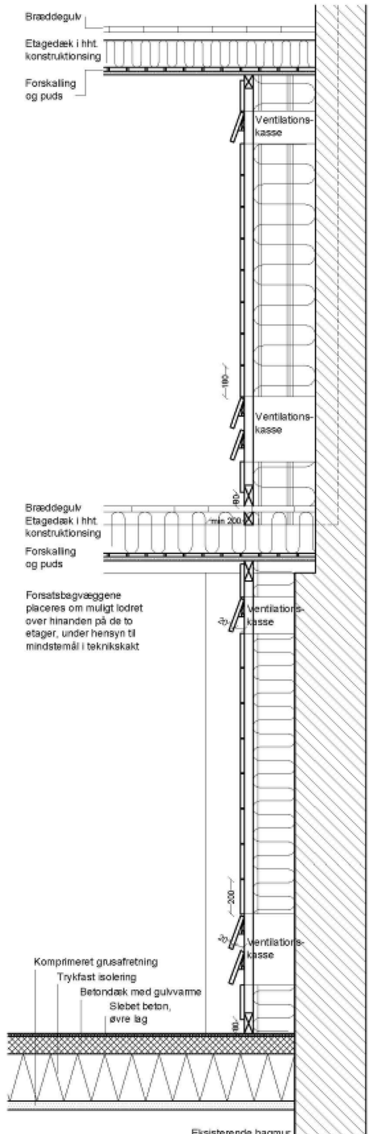




Snit bagvæg

OVERVIEW OF REJECTED AND APPROVED ENERGY SAVING INITIATIVES

Building 7,8 and 9

Nr.	Energy saving initiative	A1	A2	A3	A4	Reason for rejection of idea
Windows and solar shading						
01a	Replacement of windows with new super low energy windows					Listed status and architecture not respected
01b	New super low energy windows in new window holes					
02	New low energy secondary glazing & solar shaded external glazing					External glass can not be replaced due to architectural and listed status considerations
02a	New low energy glass in existing secondary glazing frames					Only building 8
02b	New solar shaded secondary glazing					Colour of the glass is too marked
03	New windows with internal solar shading					Listed status and architecture not respected
04	External solar shading					
Insulation and building envelope permeability						
05	Internal post/insulation of external walls					In some areas
06	External post-insulation of external walls					Listed status and architecture not respected
07	Post-insulation of sloped ceilings					Initiative does not have a large enough effect
08	Post-insulation of ground slab					
09	Use of 'superthin' insulation type					The quality of this type of insulation is unreliable and the effect is not large enough
10	Establishment of tightness in the building envelope					
Ventilation						
11	Natural ventilation - opening of windows					Poor solution in large office spaces
12	Night cooling, ventilation - intake in building envelope and exhuast in the roof					Fresh air intake through the building envelope not possible
13	Hybrid ventilation, intake in the building envelope and extraction via heat pumps					Fresh air intake through the building envelope not possible
14	Traditional mechanical ventilation via ventilation system					
15	Fresh air intake via solar walls, active glass panels					Listed status and architecture not respected
Heating, water and cooling						
16	Cooling via mechanical recirculation of air in the room					Cooling provided via the ventilation system
17	Passive cooling of the room via chilled ceiling or walls					Cooling provided via ventilation
18	Cooling where excess heat is transferred to the exhaust air					A central plant is built that supplies all the buildings
19	Cooling via earth pipes					Cooling load is not sufficient
20	Cooling via heat pumps to ground/sea water					Cooling load is not sufficient
21	Heating via radiators					
22	Under floor heating					
23	Centralised domestic hot water production					Not viable in terms of CO2
24	Decentralised domestic hot water production					
28	Rainwater harvesting					Limited water use
Electricity						
25	Energy saving light sources					
26	Daylight controlled lighting					
27	Centralised control of electrical components					
Solar panels and solar cells						
29	Solar panels for production of hot water					Listed status and architecture not respected
30	Solar panels for heating					Listed status and architecture not respected
31	Solar cells					Listed status and architecture not respected
Behavioiur and layout						
32	Moving heat producing elements from the office to a shared server room					
33	Shared cantine					
34	Shared meeting and conference facilities					
35	Storm porch in the main entrance					Listed status and architecture not respected

BUILDING 11 – HALF-TIMBERED BUILDING

WORKGROUP ASSESSMENT 1

The internal and external heritage values of the building, especially in the ground floor, meant that it was decided already in the first assessment that it was not possible to continue with a many of the energy saving initiatives that were originally suggested. For example the suggestions for external post-insulation and internal and external solar shading were rejected.

The majority of the energy saving solutions for the electrical and services installations as well as replacing the glass in the secondary glazing and increasing the tightness of the building envelope were however recommended for further development.

WORKGROUP ASSESSMENT 2

At the second workgroup assessment, the possibility of creating balanced ventilation with cooling in the ground and first floors was presented. This solution was approved for further development.
All the other proposals were again recommended for further development.

WORKGROUP ASSESSMENT 3

As part of the third workgroup assessment all the initiatives were again approved for further working.

The workgroup agreed that the following initiatives should be used to create the solution to be calculated:
1b. New super low energy windows in new window holes
2a. Energy saving glass in the existing secondary glazing frames (building 8 only)
05. Post-insulation of external walls in kitchen area and utility rooms
08. New, insulated ground slab
10. Building envelope air permeability: 0,50 h^{-1} ground floor
0,16 h^{-1} first floor
14. Balanced ventilation – base exchange rate around 12 l/s person (incl. cooling)
18. Cooling via a centrally placed unit where excess heat is transferred to the outside air
21. Radiator heating – first floor
22. Under floor heating – ground floor
24. Decentralised domestic water production
25. Energy saving light sources
26. Daylight controlled lighting
27. Centralised control of electrical components
33. Shared canteen
34. Shared meeting and conference facilities

The point numbers correspond to the points in chapter 2.

It should be mentioned that point 08 (ground slab) results in an expected CO2 reduction of 4,36%, point 10 (building envelope) a reduction of 7,27% and point 27 (centralised control of electricity) a reduction in CO2 of 7,59 %. On the other hand the necessary cooling and ventilation systems are expected to have a negative effect on the projected CO2 savings of 7,7%.

WORKGROUP ASSESSMENT 4

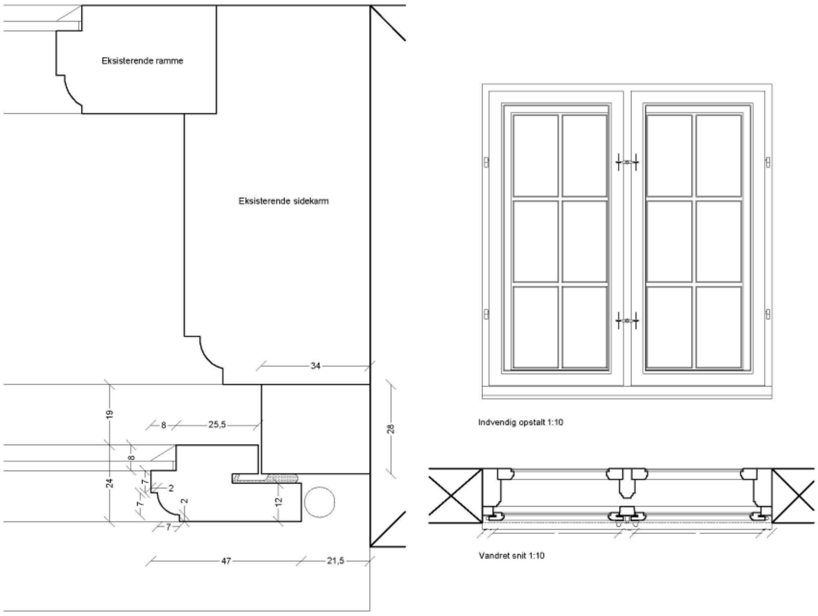
At the fourth workgroup assessment the results of the calculations were carefully reviewed. The workgroup assessed that the overall result can be expected to give a reduction in transmission loss of 57% and an overall relative CO2 reduction of 17%. Due to the change in function of the building there will be an increase in CO2 consumption of 20% compared with the existing building.
It is however possible to achieve a thermal internal climate level in class C.
All in all a satisfactory result given that, due to internal climate considerations, it will be necessary to add a significant cooling capacity. This is because the Half-timbered building is primarily planned as a service building for the other buildings in the complex, with canteen and meeting facilities in the entire ground floor. The significant cooling load has a negative influence on the expected savings in CO2.

Pt. no. Original usage:	**Heating/m2 105,7w/m2**	**Cooling/m2 -11,2w/m2**	**Electricity/m2 80,5w/m2**	**CO2 - savings**
1b	98,3	-10,8	81,8	0,74%
2a	97,5	-11,3	80,8	1,67%
04	-	-	-	-
05	49,1	13,4	80,5	12,76%
08	84,7	-13,3	80,5	4,36%
10	71,5	-13,0	80,5	7,57%
14	102,9	-10,1	85,8	-3,69%
18	-	-	-	-
21	-	-	-	-
22	-	-	-	-
24	-	-	-	-
25	106,4	-11,2	79,6	0,70%
27	111,8	10,7	70,6	7,59%
Total	**47,8**	**17,9**	**78,1**	**13,93%**

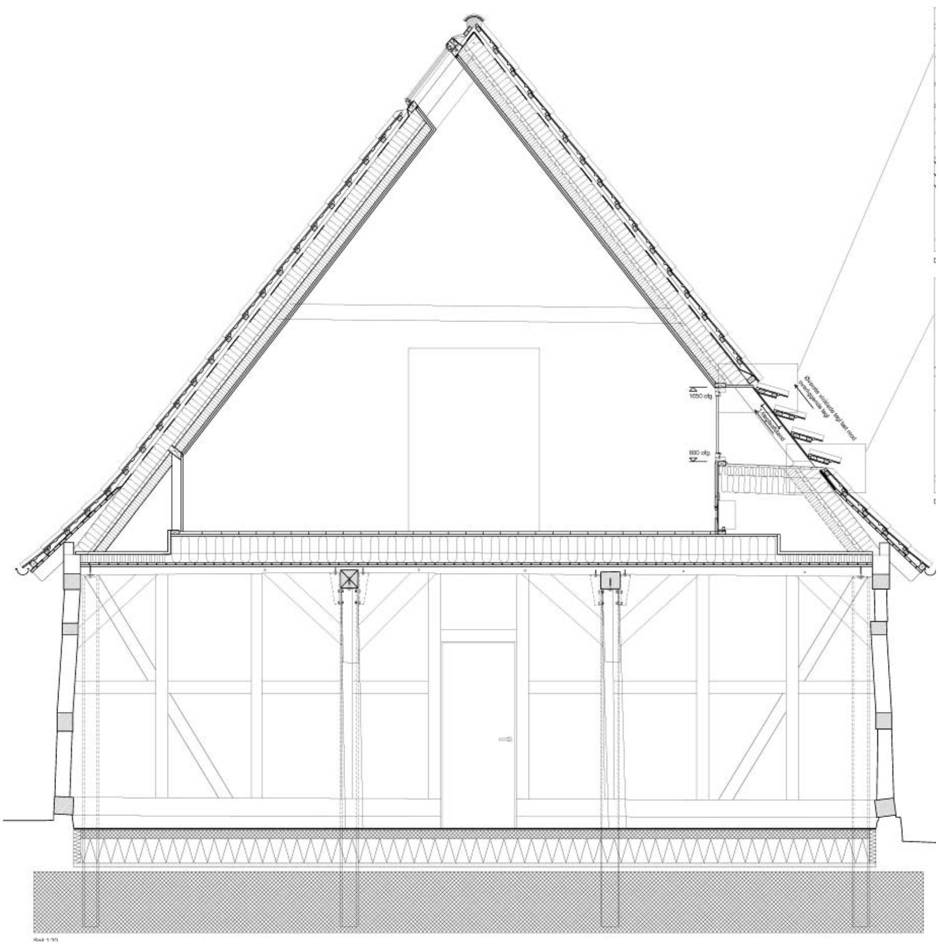
”-” These initiatives are included in the reference model, so there is no single calculation which shows the specific energy savings for that particular initiative.

BUILDING ENVELOPE

New secondary glazing frames are added to the existing windows.



The roof is post-insulted and a new ground slab is constructed.



OVERVIEW OF REJECTED AND APPROVED ENERGY SAVING INITIATIVES

Building 11

Nr.	Energy saving initiative	A1	A2	A3	A4	Reason for rejection of idea
	Windows and solar shading					
01a	Replacement of windows with new super low energy windows					Listed status and architecture not respected
01b	New super low energy windows in new window holes					
02	New low energy secondary glazing & solar shaded external glazing					External glass can not be replaced due to architectural and listed status considerations
02a	New low energy glass in existing secondary glazing frames					
02b	New solar shaded secondary glazing					Colour of the glass is too marked
03	New windows with internal solar shading					Listed status and architecture not respected
04	External solar shading					Listed status and architecture not respected
	Insulation and building envelope permeability					
05	Internal post/insulation of external walls					Listed status and architecture not respected. Can be accepted in the kitchen and utility rooms
06	External post-insulation of external walls					Listed status and architecture not respected
07	Post-insulation of sloped ceilings					Not viable in terms of CO2
08	Post-insulation of ground slab					
09	Use of 'superthin' insulation type					The quality of this type of insulation is unreliable and the effect is not large enough
10	Establishment of tightness in the building envelope					
	Ventilation					
11	Natural ventilation - opening of windows					
12	Night cooling, ventilation - intake in building envelope and exhaust in the roof					Fresh air intake through the building envelope not possible
13	Hybrid ventilation, intake in the building envelope and extraction via heat pumps					Fresh air intake through the building envelope not possible
14	Traditional mechanical ventilation via ventilation system					
15	Fresh air intake via solar walls, active glass panels					Listed status and architecture not respected
	Heating, water and cooling					
16	Cooling via mechanical recirculation of air in the room					
17	Passive cooling of the room via chilled ceiling or walls					Listed status and architecture not respected
18	Cooling where excess heat is transferred to the exhaust air					A central plant is built that supplies all the buildings
19	Cooling via earth pipes					Cooling load is not sufficient
20	Cooling via heat pumps to ground/sea water					Cooling load is not sufficient
21	Heating via radiators					
22	Under floor heating					
23	Centralised domestic hot water production					Not viable in terms of CO2
24	Decentralised domestic hot water production					
28	Rainwater harvesting					Limited water use
	Electricity					
25	Energy saving light sources					
26	Daylight controlled lighting					
27	Centralised control of electrical components					
	Solar panels and solar cells					
29	Solar panels for production of hot water					Listed status and architecture not respected
30	Solar panels for heating					Listed status and architecture not respected
31	Solar cells					Limited effect due to shading from neighbouring buildings
	Behavioiur and layout					
32	Moving heat producing elements from the office to a shared server room					
33	Shared cantine					
34	Shared meeting and conference facilities					
35	Storm porch in the main entrance					Listed status and architecture not respected

SUMMARY

The overall conclusions are:

1. It has been possible to show an expected relative CO2 reduction of 18% compared with the existing situation, whilst still showing the necessary respect for the core heritage values of the buildings. The actual reduction in CO2 can be calculated to 7,8%. The actual reduction is so much less than the relative because the indoor climate level has been raised from an unacceptable level to an acceptable level, and the complex now has 40 workstations more than before.

2. A number of the energy saving initiatives suggested initially could not be realised in the complex due to the core architectural heritage values. Similarly the engineering situation/requirements to do with the changed moisture balances in the building constructions also set limits as to which initiatives could be implemented.

3. When listed buildings are used as office spaces the thermal indoor climate, with regard to health and the working environment, is usually poor. This is usually due to the fact that earlier restorations have not been aware of the need for establishing ventilation and/or cooling when implementing classic energy saving measures such as secondary glazing, post-insulation etc.

4. The building envelope permeability tests (blower door test) that were performed on the buildings have shown large concentrated leaks in the building envelope. As well as resulting in large heat loss, these leaks also creates indoor climate discomforts in the form of draughts and asymmetrical temperature distribution in the rooms. Concentrated leaks can also affect the state of the structure of the building, as large moisture accumulation can occur in the constructions around the leaks.

5. The thermal indoor climate often has an impact on which energy saving initiatives can be implemented. The reason is that passive energy saving initiatives, for example post-insulation, frequently have an undesirable effect on the internal climate, as an increased insulation level results in an undesired higher room temperature. If the room temperate cannot be reduced to a reasonable level for a working environment through technical installations, such as ventilation or cooling, then the initiative should be rejected. This is common, as technical installations such as ventilation and cooling typically require a lot of space and are very visible, and therefore cannot be implemented in listed buildings due to the lack of supply routes. At the same time the viability in terms of CO2 of passive initiatives, such as post-insulation, should be carefully considered, as the net savings are reduced by the required (energy intensive) cooling of the room temperature in the spring and summer.

6. Electricity based energy savings in the office environment should be highly weighted in the decision making process, as these give both direct CO2 savings and derived savings as a result of a reduced cooling load in the summer season. For example reductions can be achieved through a central shut-off of power outside of working hours, which ensures that all IT devices, lights, etc. are turned off. In terms of the planning and layout

savings can be achieved by moving electrical devices which give off heat away from the office environment and to a common “technical room”.

7. The working method used in the project has led to a comprehensive approach where by it has been possible, without compromising the core heritage values, to integrate design, supply routes and energy savings. It is therefore possible to devise different solutions, that together produce energy savings, combined with the creation of an indoor climate level in Class C, which fulfils the requirements in the current Building Regulations and from the Danish Working Environment Authority for the design of permanent workplaces.

FOLLOW UP

FOLLOW UP PROCESS FOR THE OVERALL CO2-TARGET

The intention is that the follow up process for the overall CO2 target will take place from 2012-2015, where the expected savings will be documented through measurements/recordings once the complex is restored.

FOLLOW UP METHOD

The follow up with be performed via, among others, the reading of a wide range of consumption meters, which will be inbuilt during construction.
In the indoor climate area indoor climate measurements will be performed, supported by a satisfaction survey for the internal environment.