ClearingHouse Support

Clearinghouse Facilitation

RUE Technology guide

Catalogue for Project Service Facilities

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Paving Way for Better Energy Building Performance in EU Less Developed Regions

http://www.clearsupport.eu

List of contents

1. Introduction

This report is a result of the work conducted as a part of of the project “Clearinghouse Facilitation - Paving the Way for Better Energy Building Performance in EU Less Developed Regions. The project acronym is ClearSupport and the project is based on the EC’s intentions for establishing a clearinghouse for promotion of small and medium scale sustainability energy projects as stated in the EU Green Paper on Energy Efficiency. The technology focus is on RUE in building measures.

Dedicated to bring in front rational use of energy (RUE) in buildings, the main focus is on building retrofitting, and to a minor extent also designing for RUE in new buildings. A wide range of measures exists for RUE building retrofitting and must be made operational for the operation of project service facilities (PSF) and thus shall facilitate ClearingHouse penetration in general.

Latvia, Lithuania, Poland, Czech Republic and Crete have a PSF in place. The role of each PSF is to provide practical assistance to project owners on project identification, documentation and financing. Project owners include housing associations, municipalities and building project developers having the possibility to implement increased rational use of energy in larger building stocks.

The overall goal of this report “*RUE Design in Buildings*” is to develop standardised solutions to RUE in building measures. The objectives of the work are:

- To collect and prepare structured information on technical issues within building retrofitting for the use in the PSFs,
- To ensure an adequate RUE level for new buildings,
- Evaluate the impact of RUE building retrofitting,
- To generate a RUE package for PSF operation,
- To extract the replication value of the performed activities of relevance for other EU less developed regions.

This leads to the following four reports::

Ref	Report title
D.4.1	Report on cost and energy savings for RUE initiatives in buildings
D.4.2	Report on regional/local impact of RUE initiatives in buildings
D.4.3	Report on EU wide energy saving potential due to RUE initiatives
D.4.4	RUE Technology guide / catalogue for Project Service Facilities

2. Scope/structure of report

The main part of the report consists of a catalogue on RUE measures which are found to be attractive to implement in the involved regions, with the main focus on building retrofitting. The data are based partly on the findings in Report on cost and energy savings for RUE initiatives in buildings, D 4.1, and partly on experience from western European countries, primarily Denmark.

The structure of the catalogue as well as the description of a number of measures is based on Guidebook 106 from the Danish Building Research Institute, ISBN 87-563-0282-7.

Most of the suggested measures are universal and can be implemented in all types of buildings. Consequently, measures are categorized not according to building type but according to the following categories:

Constructional RUE measures

Insulation, heat conserving system (CI). This includes various forms of insulation of the building envelope.

Sealing, heat conserving system (CS). This includes various forms of sealing of the building envelope.

Utility measures - Heat generation, distribution and consumption

Reduction of losses from the heat generating system, i.e. chimney and boilers (UG). Not applicable for electrical heated buildings or buildings heated by district heating.

Reduction of losses from the heat distribution system, i.e. pipes systems (UD). This includes temperature controls and insulation of pipes and fittings.

Reduction of superfluous consumptions from heat consuming systems, i.e. radiators etc. (UC). This includes various forms of automatic controls.

Utility measures - ventilation

Reduction of energy consumption for ventilation purposes (UV). This includes heat recovery and insulation of ducts.

Utility measures - water for domestic use

Reduction of energy consumption for domestic hot water (UDW). This includes control systems, insulation, heat recovery and solar heating.

Utility measures - Electrical

Reduction of electrical energy consumption for lighting, pumps and ventilation fans.

Each RUE measure is described according to the following structure:

Basic principle

A sketch or short description of the RUE measure
Description of how the energy savings are obtained
Special conditions to be observed

Investment and savings

Key figures on
Capital investment
Maintenance costs
Savings
Expected technical lifetime
Labour intensity

The cost effectiveness of the measure is characterized by the Cost of Saved Energy (CSE), defined as the total estimated investment divided by the estimated saved energy during the lifetime, not considering inflation. Additional maintenance during the lifetime, if any, should be included in the total investment.

If the calculated CSE for the measure (€/kWh) is less than the actual unit-price of the saved energy, it is considered feasible to implement the measure. An estimated average unit-price for energy during the lifetime can be used for this purpose.

Example

Assumed technical lifetime:	20	yr
Estimated investment:	10,000	€
Additional maintenance:	200	€/yr
Total estimated investment: 10,000,- + 200 * 20 =	**14,000**	**€**
Estimated energy saving:	20	MWh/yr
Total estimated energy saving: 20 * 20 =	**400**	**MWh**
Cost of Saved Energy (CSE): 14,000,- / 400 =	**35**	**€/MWh**
Actual unit-price:	40	€/MWh
The measure is feasible, as CSE (35) < Actual unit-price (40)		

Application

Description of the types of buildings or systems, where the measure can be applied. Different variants can also be described.
The regions or countries, where the measure typically will have the largest impact.

Implementation

Comments on how and when the measure could be carried out without unnecessary complications, e.g. in connection with other work or need for special planning. Special cautions to be considered.

Supervision/Quality assurance

Indications of how to verify the quality of the work carried out. Especially where the work is concealed when finished.

Maintenance

If the measure induces additional maintenance for realizing the estimated savings, indications of the required maintenance will be given. If available, the approximate yearly maintenance costs are noted.

Side effects

Comments on side effects, if any, which the implementation of the measure could result in. Negative as well as positive side effects are noted.

2.1 General assumptions

For each measure, the specific assumptions are stated in the Investment and savings field. Assumptions which are valid for all measures are described in the following.

2.1.1 Investments

Investment costs are estimated on the base of information from the local project service facilities to the extent this has been available. In the absence of such information, estimates are based on Danish prices [Ref. V&S Prisdata, Renovering og drift, Byggecentrum, 2008], adjusted for local costs of labour and materials.

All investments are calculated for the measure being carried out on its own. Measures, which have a high cost of saved energy, CSE, can turn out to be feasible if carried out in connection with work to be done for general renovation purposes. To example, extra insulation of the roof will often be feasible, if carried out when the roof is renovated anyway. It will then be necessary to calculate the marginal cost for carrying out the RUE measure.

In some cases, it can be desirable to carry out two or more RUE measures at the same time. This will sometimes also reduce the total investment to less than the sum of the individual investments. However, one should be aware that the total energy saving can be reduced too. An exception to this is insulation of the building envelope, where the energy saving for each measure usually can be added directly.

In some of the examples investment costs are only available from Danish sources. In these cases the costs are reduced with 38 % for Eastern countries to take into account the lover salary and general cost levels in these areas.

2.1.2 Maintenance cost

RUE measures such as extra insulation, exchange of windows etc., will not induce additional maintenance costs, as the maintenance of the existing surface was the same. A change of surface can however give a variation in maintenance costs, both up and down.

For RUE measures where new installations are introduced, an additional maintenance cost must be envisaged. For mechanical installations, the maintenance costs are usually estimated as 2-4 % of the initial investment.

2.1.3 Labour intensity

For the purpose of estimating the social and economical impact for the regions, an indicator of whether the measure requires a low, medium or high labour intensity is given. As this indicator is subject to variations between various regions, it should be further evaluated in each case.

2.1.4 Technical lifetime

For calculating the cost of saved energy, CSE, the following technical lifetimes are used, unless otherwise stated:

Insulation of protected structures, e.g. cavity insulation:	40 years
Other insulation works, new windows and heating and cooling systems:	20 years
Renovation of boilers:	10 years
Light fixtures:	10 years
Automatic controls:	10 years
Sealing works:	5 years

These figures are equivalent to the figures set in the Danish Building Regulations to determine feasibility of energy saving measures.

2.1.5 Climate data

The energy savings that the RUE measures imply are adjusted to the relevant climate zones for the individual regions. This is based on the “New European Heat Index” (EHI) taken from [Ref: Werner, S., The new European heating index, 2006]. Figure 1 shows the climatologically demands for space heating as an index. The index is calibrated so 100 equals an average European condition. The EHI is based on data (degree days) from 80 locations. European heat index values for selected European locations are shown in Table 1.

Location	EHI
Amsterdam	99
Athens	62
Barcelona	71
Belgrade	94
Bratislava	103
Brno	108
Krakow	111
Odessa	103
Prague	112
Riga	116
Roma	72
Skopje	96
Sofia	103
Talinn	121
Tirana	78
Vilnius	118
Zagreb	95
Aalborg	112

Table 1: European heat index (EHI) values for locations selected from the 80 locations employed in the establishment of the EHI.

For locations not mentioned in table 1, figure 1 will be used for estimating the heat index.

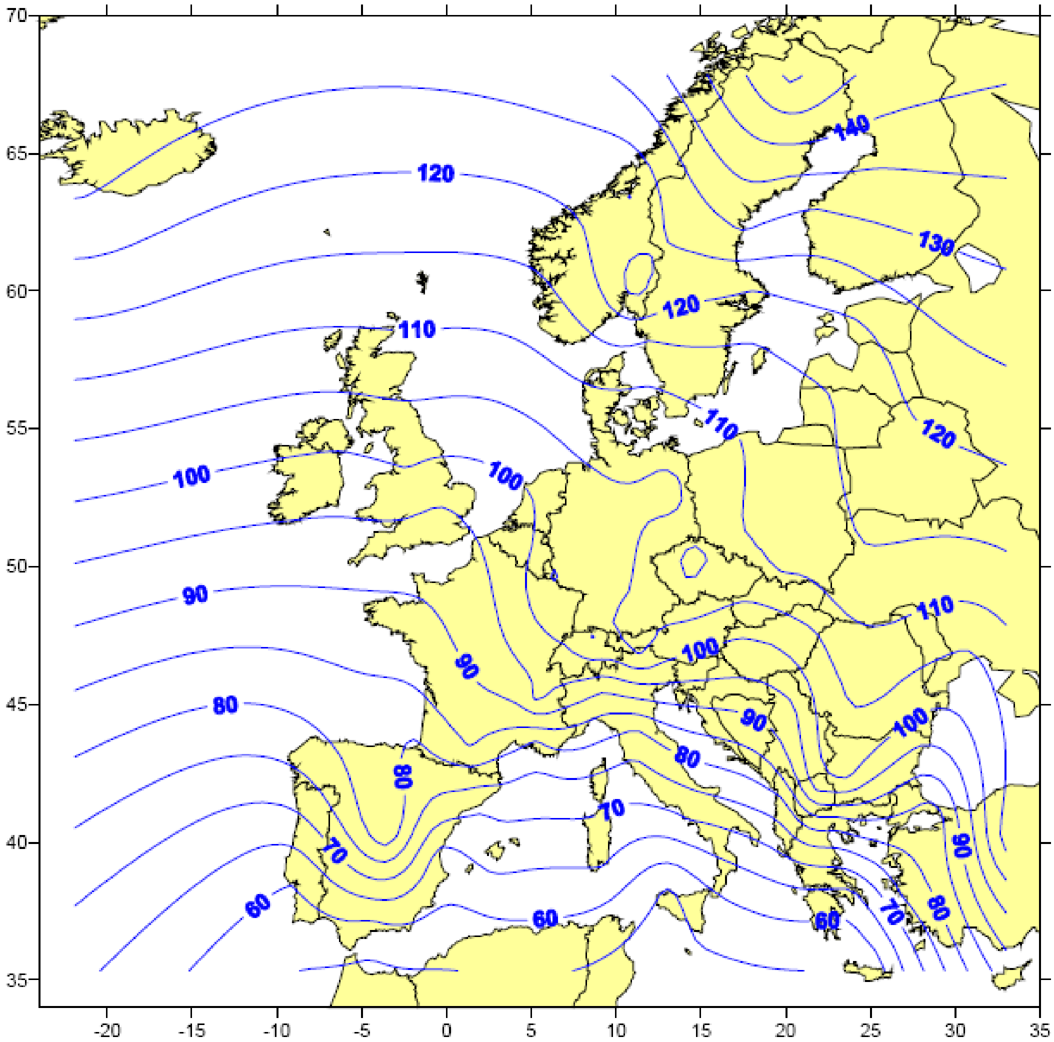


Figure 1: The new European heat index (EHI) in a contour map computed from information for 80 urban locations in Europe. The space heating demand is assumed to be proportional to this index. Note that the map is not representative for all locations in each country, since the existing data grid consists of only 80 locations [Ref: Werner, s., The new European heating index, 2006].

2.1.6 Energy prices

Energy prices for four different energy commodities (gas oil, district heating, natural gas and electricity) have been collected from the five PSFs and Slovenia. The prices are average prices as of May and June 2008 including all taxes and VAT. For business, organisations and enterprises deductible VAT is not included.

	Gas oil		District heating		Natural gas		Electricity	
	Households	Business	Households	Business	Households	Business	Households	Business
Latvia	110	110	56	63	32	38	101	100
Lithuania	83	71	47	44	39	31	96	90
Poland	143	132	51	51	68	60	132	138
Czech Rep	-	-	60	60	60	50	148	140
Slovenia	92	92	36	41	46	45	110	110
Crete	140	-	-	-	-	-	110	-

Table 2: Energy prices in EURO/MWh for gas oil, district heating, natural gas and electricity. "Business" covers business, organisations and enterprises. The prices are collected from the five PSFs and Slovenia in May and June 2008 and are average prices. Gas oil is not employed in Czech Republic. Solely gas oil and electricity for households are relevant for Crete.

3. RUE measures

3.1 Constructional RUE measures (CI and CS)

Constructional energy saving measures are taken in order to improve the thermal insulation and tightness of the building envelope.

Further, the thermal comfort in the building is improved, as the temperature of the internal surfaces is increased and draught is reduced. Due to this the air temperature can often be lowered without reducing the comfort and thus energy savings can be obtained.

CI 1: Insulation of roof and roof top insulation

Basic principle

A: Flat roof

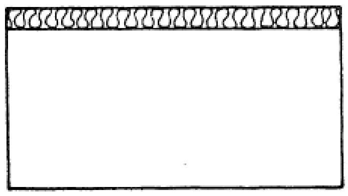
Internal insulation in the form of:

Mineral wool between laths

Pasted insulation plates

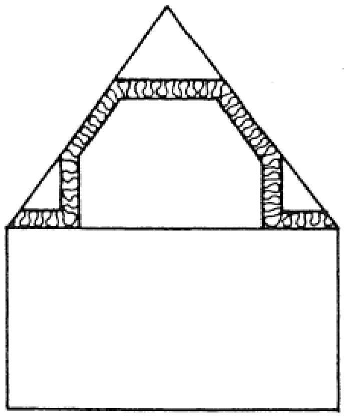
Insulated suspended roof

External insulation is placed on the existing roof top and new roofing felt is placed on top of the insulation.



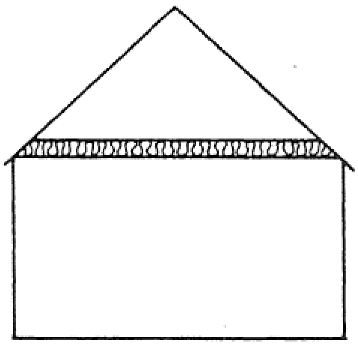
B: Utilized roof floor

Mineral wool is placed between the rafters at the slope of the roof and at the roof slope wall. The insulation is secured with 2 mm galvanized thread or shutter boards.



C: Not utilized roof floor

Mineral wool batts are placed directly on the roof construction, possibly establishment of a walkway.



The energy saving is obtained by reducing transmission losses through the building envelope.

Investment and savings

Types A and B

Existing U-value: 1.00 W/m2K

Extra insulation: 100 mm

Region	Baltic Region	Central Europe	Southern Europe
Initial investment, I, €/m2	36-54	36-54	36-54
Maintenance cost, M, €/m2 p.a.	0	0	0
Labour intensity	High	High	High
Technical Lifetime, n, years	20-30	20-30	20-30
Energy savings, □E, kWh/m2 p.a.	66-98	60-90	40-60
Cost of Saved Energy, CSE ((I+n*M)/(n*□E)), €-cent/kWh	1.2-4.1	1.3-4.5	2.0-6.8

Type C

Existing U-value: 1.00 W/m2K

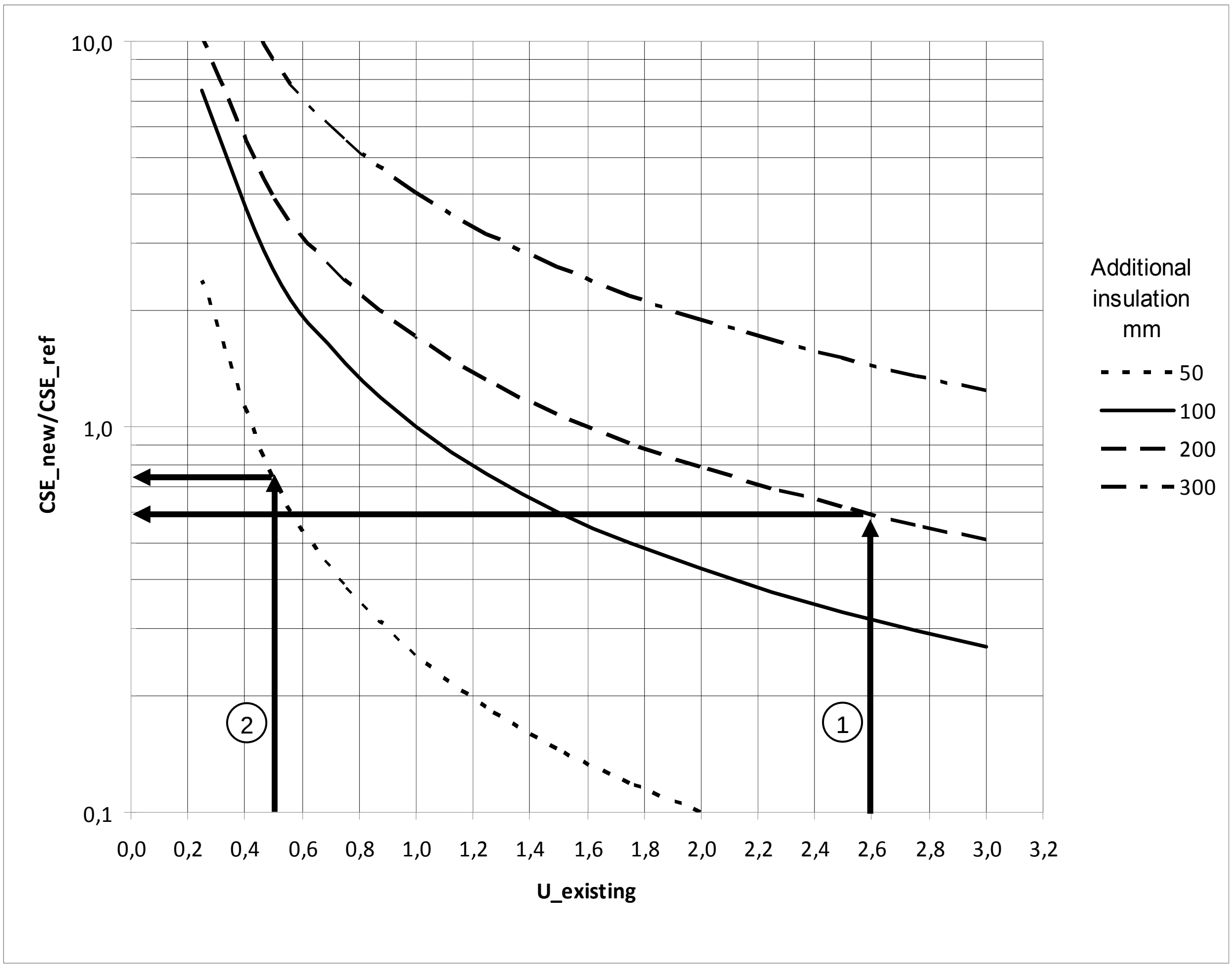
Extra insulation: 100 mm

Region	Baltic Region	Central Europe	Southern Europe
Initial investment, I, €/m2	12-20	15-25	14-22
Maintenance cost, M, €/m2 p.a.	0	0	0
Labour intensity	Low	Low	Low
Technical Lifetime, n, years	20-30	20-30	20-30
Energy savings, □E, kWh/m2 p.a.	66-98	60-90	40-60
Cost of Saved Energy, CSE ((I+n*M)/(n*□E)), €-cent/kWh	0.7-1.5	0.6-2.0	0.8-2.7

For other U-values of the existing structure and for other additional insulation thickness, the diagram below gives an indication of the ratio between the actual CSE and the CSE calculated above.

Example 1:
The existing structure has a U-value of 2.6.
200 mm additional insulation is mounted. The CSE will be 0.6 times the CSE calculated above.

Example 2:
The existing structure has a U-value of 0.5.
50 mm additional insulation is mounted. The CSE will be 0.75 times the CSE calculated above.



Application

According to type of roof.

Implementation

The measures can immediately be implemented on roof type C and on also A for external insulation. Regarding roof type B and internal insulation for type A it is favourable to perform the work in relation to other works.

Supervision/Quality assurance

For the roof types A and B the inspection is easiest done while the work is in progress, while regarding roof type C the inspection can as well be done subsequently. For all roof types applies that finalized work also can be inspected by the use of thermography.

Maintenance

There are no specific requirements regarding maintenance. Compression of the insulation shall be avoided (possibly by establishment of a walkway, type C only).

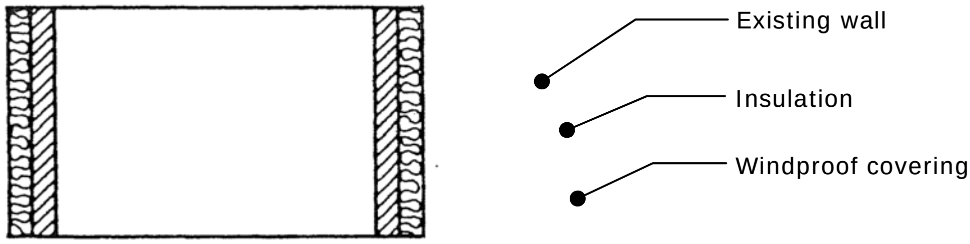
Side effects

If the work is performed correctly, there are no side effects related to these measures. Flaws in the implementation can cause problems with damp, which can lead to reduced insulation power or damage to the woodwork (dry rot). Special attention shall be on the internal insulation work in order to avoid these adverse side effects. It shall be mentioned that internal insulation reduces the height of the room.

Constructional RUE measures

CI 2: External insulation of exterior wall

Basic principle



The insulation is placed on the exterior wall in a framework of pressure-impregnated wood or metal rails. The insulation material is covered by a windproof layer and is closed with plating. A ventilated air space shall be established behind the plating. Alternatively, chicken wire and plaster directly on the insulation material can be used for closing.

The energy saving is obtained by reducing transmission losses through the building envelope.

Investment and savings

Existing U-value: 1.00 W/m2K

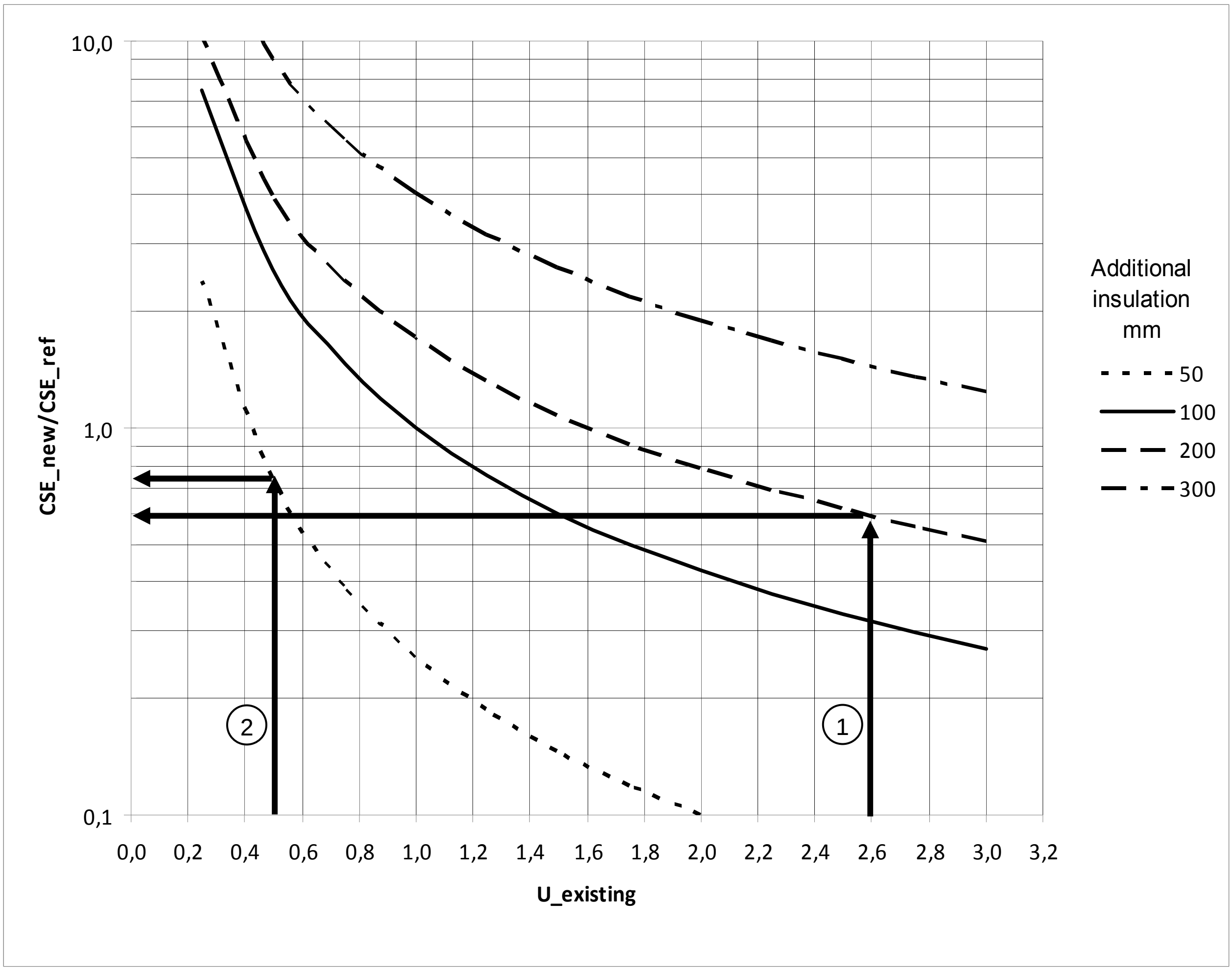
Extra insulation: 100 mm

Region	Baltic Region	Central Europe	Southern Europe
Initial investment, I, €/m2	46-69	46-69	46-69
Maintenance cost, M, €/m2 p.a.	0	0	0
Labour intensity	Medium	Medium	Medium
Technical Lifetime, n, years	20-30	20-30	20-30
Energy savings, □E, kWh/m2 p.a.	77-115	70-105	47-70
Cost of Saved Energy, CSE ((I+n*M)/(n*□E)), €-cent/kWh	1.3-4.5	1.5-4.9	2.2-7.4

For other U-values of the existing structure and for other additional insulation thickness, the diagram below gives an indication of the ratio between the actual CSE and the CSE calculated above.

Example 1:
The existing structure has a U-value of 2.6.
200 mm additional insulation is mounted. The CSE will be 0.6 times the CSE calculated above.

Example 2:
The existing structure has a U-value of 0.5.
50 mm additional insulation is mounted. The CSE will be 0.75 times the CSE calculated above.



Application

External insulation of exterior walls can typically be applied to panel buildings where there is a wish to upgrade the architectural expression of the building.

Implementation

The work can be immediately implemented for all three measures. However, internal insulation should be undertaken while other works are ongoing (e.g. renovation).

Supervision/Quality assurance

Regarding external insulation where the insulation material is covered by plating or the like inspection shall be done while the work is ongoing. The inspection of cavity wall insulation is challenging. Thermography can possibly be employed.

Maintenance

In the case of external insulation it is favourable to choose new façade materials which require limited maintenance compared to the old ones.

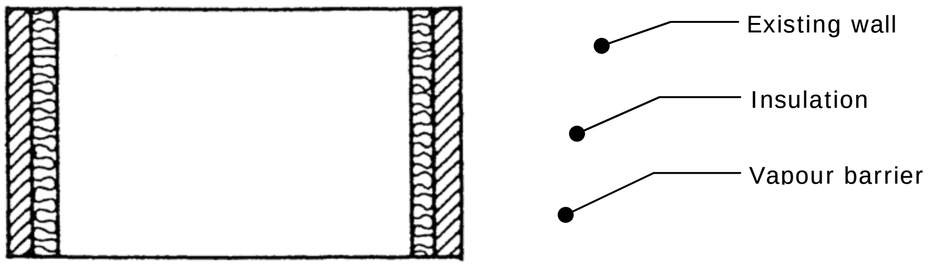
Side effects

The external insulation can cause problems of an aesthetic nature as façades are given a new surface. Further, there can be problems at the joining at the existing windows.
Internal insulation can result in condensate problems on the original wall's surface. In order to prevent transportation of damp a careful sealing along the edges of the new wall's surface shall be secured.

Constructional RUE measures

CI 3: Internal insulation of exterior wall

Basic principle



The insulation is fixed to the exterior wall by metal or wooden framework and covered by a vapour barrier and plating. Possibly prefabricated sandwich elements made of insulation material with a membrane and plate can be mounted directly on the wall. Tighten efficiently between the elements in order to avoid transportation of damp.

To avoid later penetration of the vapour barrier, it can be placed 50 mm from the surface. Calculation of the minimum temperature at the barrier should be carried out, to ensure that condensation cannot take place.

The energy saving is obtained by reducing transmission losses through the building envelope.

Investment and savings

Existing U-value: 1.00 W/m2K

Extra insulation: 100 mm

Region	Baltic Region	Central Europe	Southern Europe
Initial investment, I, €/m2	25-37	30-46	26-38
Maintenance cost, M, €/m2 p.a.	0	0	0
Labour intensity	Medium	Medium	Medium
Technical Lifetime, n, years	20-30	20-30	20-30
Energy savings, □E, kWh/m2 p.a.	70-106	64-96	43-64
Cost of Saved Energy, CSE ((I+n*M)/(n*□E)), €-cent/kWh	0.8-2.6	1.1-3.6	1.3-4.5

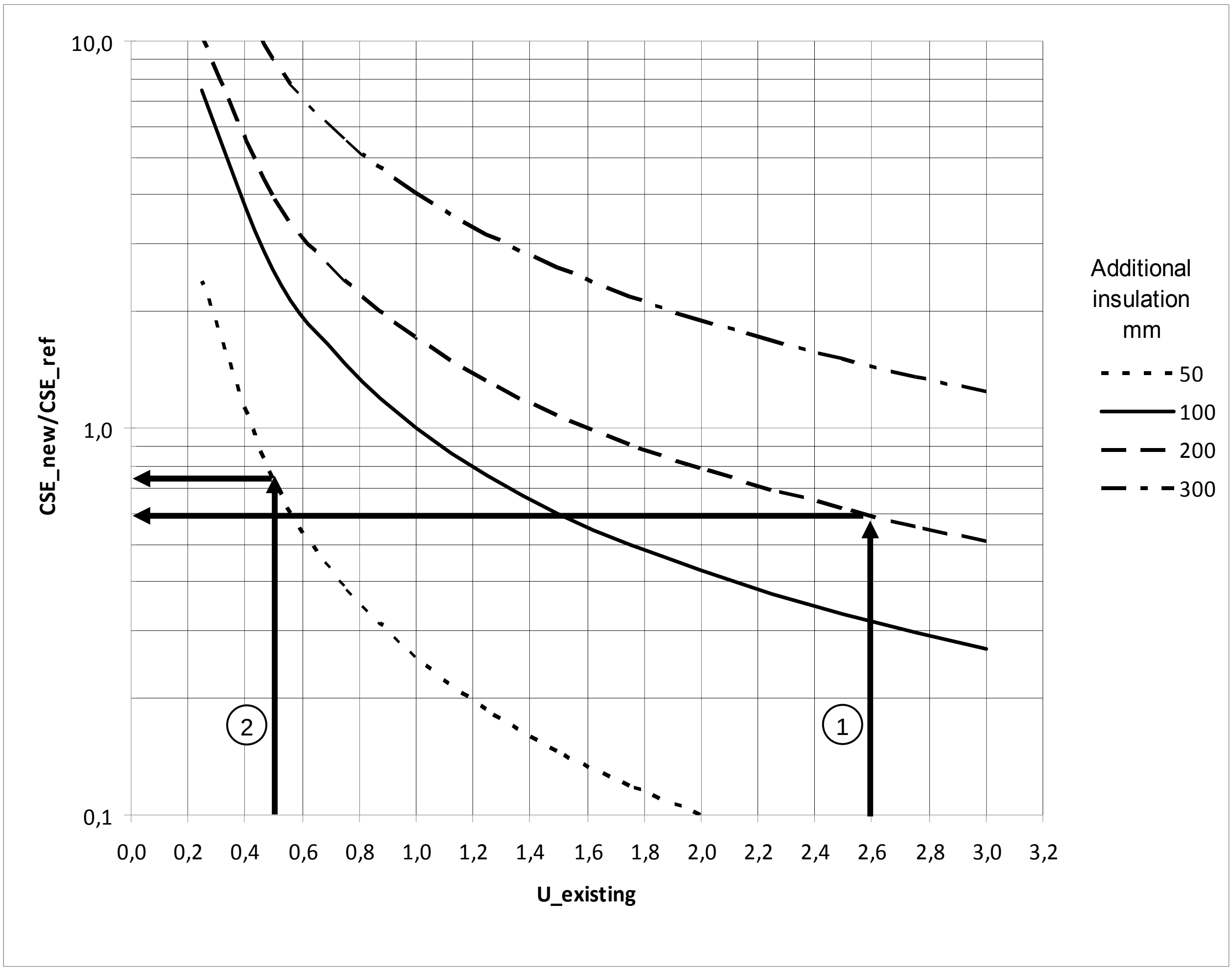
For other U-values of the existing structure and for other additional insulation thickness, the diagram below gives an indication of the ratio between the actual CSE and the CSE calculated above.

Example 1:

The existing structure has a U-value of 2.6. 200 mm additional insulation is mounted. The CSE will be 0.6 times the CSE calculated above.

Example 2:

The existing structure has a U-value of 0.5. 50 mm additional insulation is mounted. The CSE will be 0.75 times the CSE calculated above.



Application

Internal insulation can be applied to all type of buildings.

In rooms with a high production of humidity other solutions should however be preferred, due to the risk of condensation inside the wall.

Implementation

The work can be immediately implemented. However, internal insulation should be undertaken while other works are ongoing (e.g. renovation).

Additional work as a result of internal insulation can be relocation of electrical outlets and pipes for heating system.

Supervision/Quality assurance

Regarding external insulation where the insulation material is covered by plating or similar inspection shall be done while the work is ongoing.

Maintenance

No additional maintenance.

Side effects

Internal insulation can result in condensate problems on the original wall's surface. In order to prevent transportation of damp a careful sealing along the edges of the new wall's surface shall be ensured. The result of condensation inside the wall will be growth of mould causing health problems for the inhabitants.

If the vapour barrier is penetrated at a later state, e.g. by nails or screws, the damp proofing is lost.

The dimensions of the room are reduced.

CI 4: Floor insulation

Basic principle

Floor above crawl space:

A1 Insulation on under side of crawl space deck. Laths and mineral wool suspended with 2 mm. galvanized thread or shutter boards. In case of joist layer without lathing on the under side the insulation can be placed between the joists.

A2 Injection of insulation material in cavity between joists in joist layer.

A3 Pasting of insulation mats on the under side of concrete deck.

Floor against terrain:

B1 Removal of existing floor, laying out of insulation and possibly vapour barrier and remounting of floor.

B2 Insulation with mineral wool mats on outer side of foundation wall.

Floor above basement:

C1 Insulation on under side of basement deck. Laths, mineral wool and covering plates.

C2 Injection of insulation material in cavity between laths in joist layer.

The energy saving is obtained by reducing transmission losses through the building envelope.

Investment and savings

Existing U-value: 1.00 W/m2K

Extra insulation: 100 mm

Region	Baltic Region	Central Europe	Southern Europe
Initial investment, I, €/m2	24-36	27-41	26-38
Maintenance cost, M, €/m2 p.a.	0	0	0
Labour intensity	Medium	Medium	Medium
Technical Lifetime, n, years	30	30	30
Energy savings, □E, kWh/m2 p.a.	55-83	50-76	34-50
Cost of Saved Energy, CSE ((I+n*M)/(n*□E)), €-cent/kWh	1.0-3.3	1.2-4.0	1.7-5.7

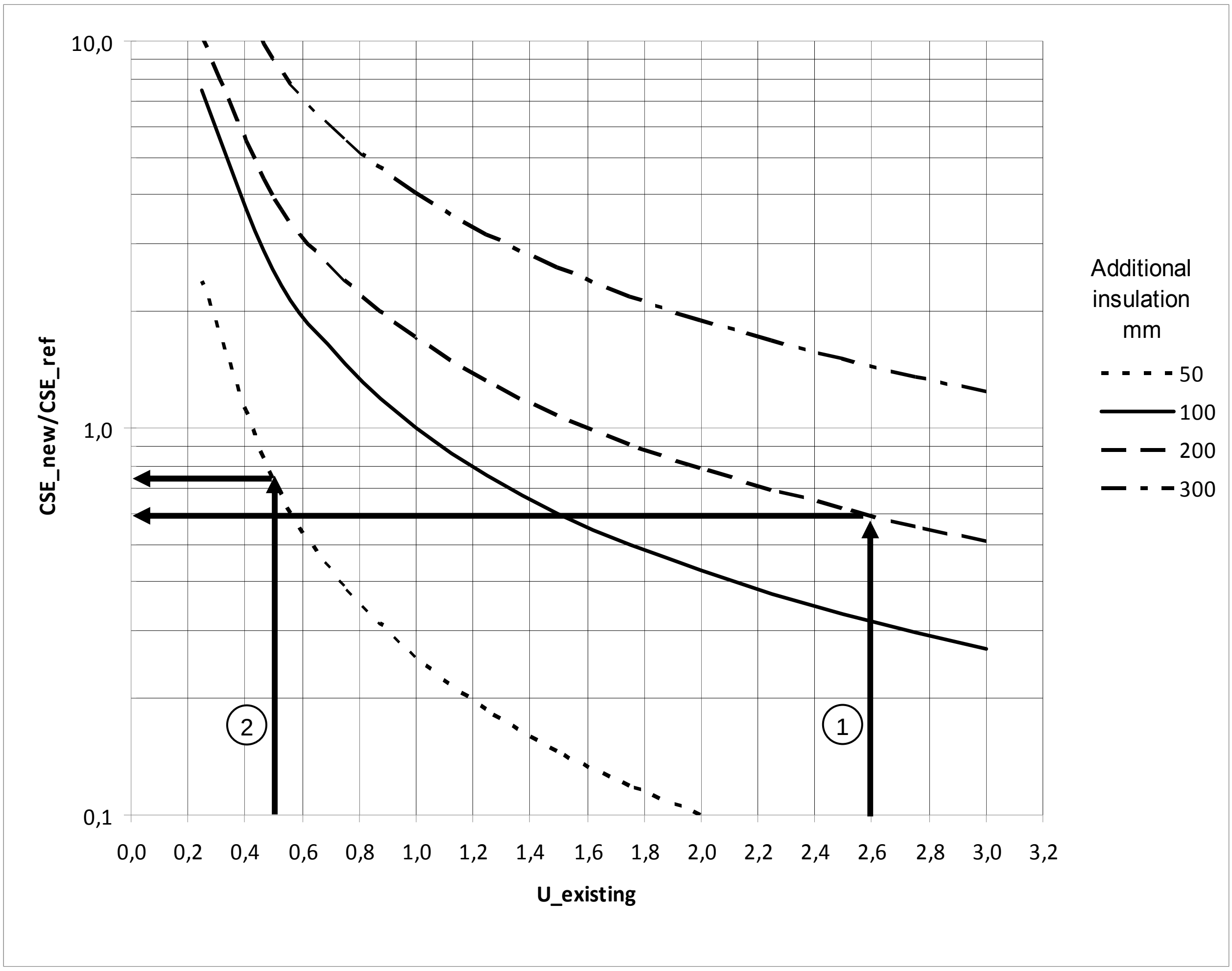
For other U-values of the existing structure and for other additional insulation thickness, the diagram below gives an indication of the ratio between the actual CSE and the CSE calculated above.

Example 1:

The existing structure has a U-value of 2.6. 200 mm additional insulation is mounted. The CSE will be 0.6 times the CSE calculated above.

Example 2:

The existing structure has a U-value of 0.5. 50 mm additional insulation is mounted. The CSE will be 0.75 times the CSE calculated above.



Application

According to type of construction.

Implementation

Insulation over crawl space and basement can be implemented immediately. For type B insulation of floor against terrain applies that where the insulation includes laying of new floor, the work should not be initiated without careful planning of a possible total renovation. Insulation of foundation wall, measure B2, can be done immediately.

Supervision/Quality assurance

Inspection of the work can be done both during implementation and subsequently.

Maintenance

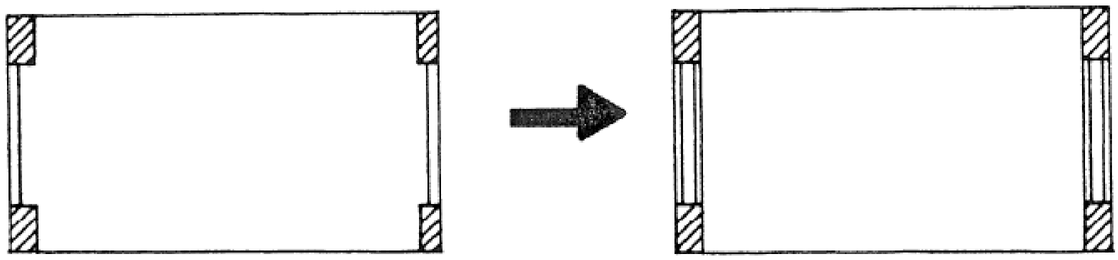
There are no specific requirements regarding maintenance in relation to these measures.

Side effects

Regarding implementation of measure B1 a vapour barrier shall be mounted on the hot side of the insulation in order to prevent problems with damp. Also regarding type C this should if possible be done, as condensate forming in the basement deck can occur.

CI 5: Insulation with multiple layer glass in windows

Basic principle



1. Mounting of removable double glazing (i.e. including casement and frame)
2. Mounting of removable pane (i.e. excluding casement and frame)
3. Replacement of window with window with sealed double glazing
4. Replacement of window with window with sealed triple glazing

Windows with double and triple glazing are also called thermo pane and insulating glass.

The energy saving is obtained by reducing transmission losses through the building envelope.

Investment and savings

U-value reduced from 2.50 to 1.10.

Region	Baltic Region	Central Europe	Southern Europe
Initial investment, I, €/m2	80-120	80-120	80-120
Maintenance cost, M, €/m2 p.a.	0	0	0
Labour intensity	Medium	Medium	Medium
Technical Lifetime, n, years	up to 15	up to 15	up to 15
Energy savings, □E, kWh/m2 p.a.	112-168	102-153	68-102
Cost of Saved Energy, CSE ((I+n*M)/(n*□E)), €-cent/kWh	3.2-10.7	3.5-11.7	5.2-17.6

Application

Buildings where existing window casements and frames are in good condition but have only one layer of glass.

Implementation

All measures can be done immediately in all building types where existing frame and casements can be used. If this is not the case these measures should be undertaken in relation to other building improvement works. However, it can be possible to replace the window casement and frame from outside with only little inconvenience.

Supervision/Quality assurance

For mounting of removable double glazing no inspection is needed. However, it is important that the secondary window/pane is applied with weather strips. For sealed glazing it shall be ensured that mounting is done according to guidelines from the supplier.

Maintenance

Secondary panes and windows induce increased cleaning demand. For removable glazing, casement, frame, weather strips etc. shall be cleaned according to guidelines from supplier. Maintenance-free casements and frames (e.g. produced from plastic or aluminium) can possibly be employed.

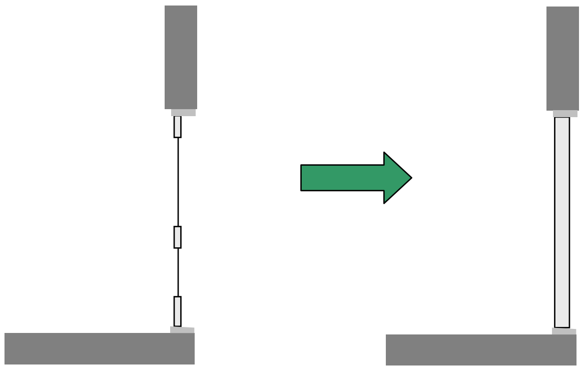
Side effects

In the winter time secondary panes and windows will regularly result in dew on the existing glass as the hot and moist indoor air to a greater or lesser extent has access to the space between the two layers of glass.

Constructional RUE measures

CI 6: New insulated entrance doors

Basic principle



Existing panelled entrance doors are replaced with better insulated doors.

Savings are achieved by reduction of the transmission loss through the door construction.

Investment and savings

The investment is calculated for dwellings of with a floorage of 50 m2.

Region	Baltic Region	Central Europe	Southern Europe
Initial investment, I, €/m2	10-15	10-15	10-15
Maintenance cost, M, €/m2 p.a.	0	0	0
Labour intensity	Low	Low	Low
Technical Lifetime, n, years	20	20	20
Energy savings, ΔE, kWh/m2 p.a.	3-5	3-4	2-3
Cost of Saved Energy, CSE ((I+n*M)/(n*ΔE)), €-cent/kWh	11.1-24.0	11.7-26.3	17.6-39.5

Application

The measures can be applied for all buildings.

Implementation

Better insulation of the entrance door will be most feasible if the existing door is due for replacement for other reasons.

Supervision/Quality assurance

No special supervision or quality assurance is needed during replacement, as the door can be inspected subsequently.

Maintenance

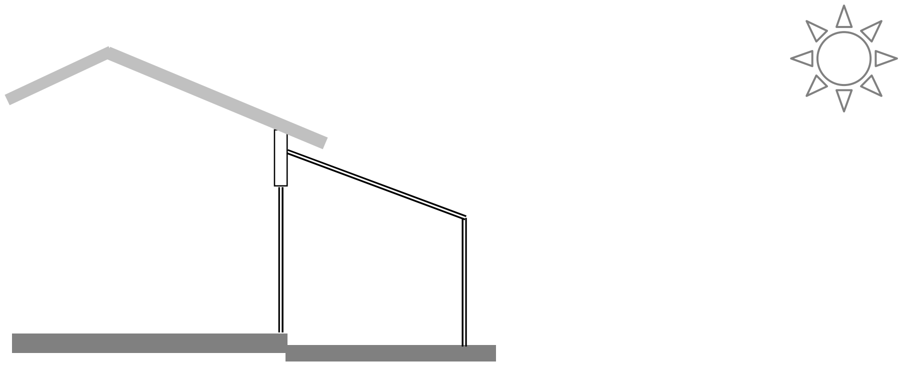
The improvement does not result in any additional maintenance.

Side effects

The entrance corridor will be less cold.

CI 7: Loggia glazing

Basic principle



Loggias or patios adjacent to the building can be closed in by glazing.

The energy saving is achieved by increasing solar gain through glazed areas, while maintaining the insulation of the building envelope. The temperature in the glazed area will rise considerably above the ambient temperature, thus reducing transmission losses through the original building envelope.

Investment and savings

The investments and savings are calculated for dwellings. It assumed that glazing of loggias imply a heat saving corresponding to up to 10 % of the heat consumption. Further, it is assumed that the area of the glazing is 9 m2 and the floorage of the apartment is 50 m2.

Region	Baltic	Central Europe	Southern Europe
Initial investment, I, €/m2	35-52	35-52	35-52
Maintenance cost, M, €/m2 p.a.	0	0	0
Labour intensity	Medium	Medium	Medium
Technical Lifetime, n, years	30	30	30
Energy savings, □E, kWh/m2 p.a.	13-19	12-18	8-12
Cost of Saved Energy, CSE ((I+n*M)/(n*□E)), €-cent/kWh	6.0-13.5	6.6-14.8	9.9-22.2

Application

Glazing of loggias or patios will be most effective if done on the southern side of the building.

The effect can be reduced by shading trees.

Implementation

Glazing can be done quite simple, as the construction does not have to be completely sealed.

Supervision/Quality assurance

Only visual inspection will be necessary to ensure proper workmanship.

Maintenance

The frames will need periodical painting and the glass panes shall be cleaned.

Side effects

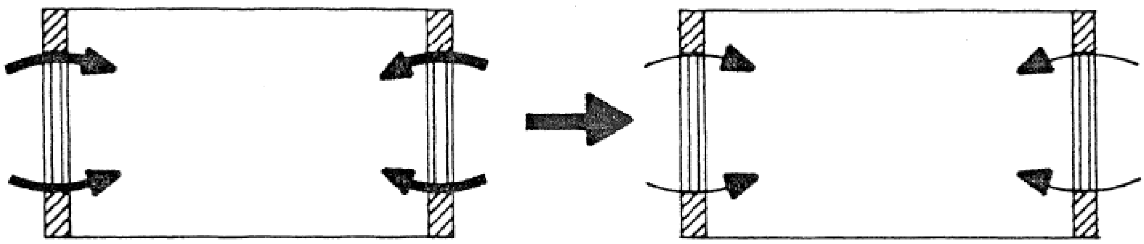
On sunny summer days, the temperature in the glazed area can be uncomfortable high. The enclosure should be provided with efficient venting for these occasions.

There is a risk of the glazed area becoming an extension of the dwelling area, also during the heating season. If doors are left open between the original building and the glazed area during winter, it can result in increased energy consumption.

Constructional RUE measures

CS 1: Sealing of windows and doors

Basic principle



Self-adhesive soft PVC foam strips are used in rabbets on windows and doors for draught prevention. Alternatively the tightening can be done with soft rubber beads fixed by hard plastic or wooden strips which are nailed to the pane optionally in a milled track.

Joints between casement and walls are sealed off by filling, backing strips and flexible filler.

The energy saving is obtained by reducing ventilation losses through the building envelope.

Investment and savings

Region	Baltic	Central Europe	Southern Europe
Initial investment, I, €/m	2-3	2-3	2-3
Maintenance cost, M, €/m2 p.a.	0	0	0
Labour intensity	Low	Low	Low
Technical Lifetime, n, years	5	5	5
Energy savings, □E, kWh/m2 p.a.	5-8	5-7	3-5
Cost of Saved Energy, CSE ((I+n*M)/(n*□E)), €-cent/kWh	5.9-13.4	6.5-14.6	9.8-21.9

Application

Buildings, where the natural draught through leakages in the building envelope causes excessive ventilation losses and draught.

Implementation

All measures can be done immediately.

Supervision/Quality assurance

Can be done both during work and subsequently. Regarding tightening of joints along casement fillings shall be inspected prior to sealing.

Maintenance

Increased dew formation can require more frequently preventive maintenance.

Side effects

By tightening of windows and doors the natural air change can be reduced so much that the air quality is reduced significantly. On the other hand draught problems are reduced. Further, increased dew formation on window surfaces and in other building components can occur due to increased relative humidity in the rooms.

Care should be taken to air the rooms frequently.

3.2 Utility measures - Heat generation

In general energy savings related to heating in buildings can be divided into two categories; increasing the efficiency of the heat supply and decreasing the consumption of heat.

Whereas the constructional RUE measures (CI1-7 and CS1) are related to decreasing the heat consumption by improving the building envelope the measures presented in the following are related to improving the efficiency of the heat supply system, including heat generating plant (e.g. a boiler).

Utility measures - Heat generation

UG 1: Insulation of boiler

Basic principle

Mounting of extra insulation on the boiler.

The energy saving is obtained by reducing heat loss to the boiler room. The saving in terms of percentage is largest for smaller and older plants.

Investment and savings

The values in the table are based on insulation of boiler. The building comprises 50 flats and the heat demand is set to 8 MWh/year per flat in the Baltic region and Central Europe and 5 MWh/year for Southern Europe. It is estimated that installation of insulation of the boiler leads to a reduction of fuel consumption by 1-5 %. The existing boiler has an efficiency of 85 %.

Region	Baltic	Central Europe	Southern Europe
Initial investment, I, €/m2	0.17	0.17	0.17
Maintenance cost, M, €/m2 p.a.	0.5 % p.a. of the initial investment		
Labour intensity	High	High	High
Technical Lifetime, n, years	10	10	10
Energy savings, □E, kWh/m2 p.a.	2-9	2-9	1-6
Cost of Saved Energy, CSE ((I+n*M)/(n*□E)), €-cent/kWh	0.2-1.0	0.2-1.0	0.3-1.5

Application

Can be applied to all building types that are supplied by individual boiler plant.

Implementation

Mostly, the work can be undertaken while the boiler is in operation.

Supervision/Quality assurance

The work can be inspected by spot tests of thickness and quality of insulation.

Maintenance

The operational personnel are to be instructed to continuously check the insulation for damages as e.g. leaking water reduces the insulation property seriously.

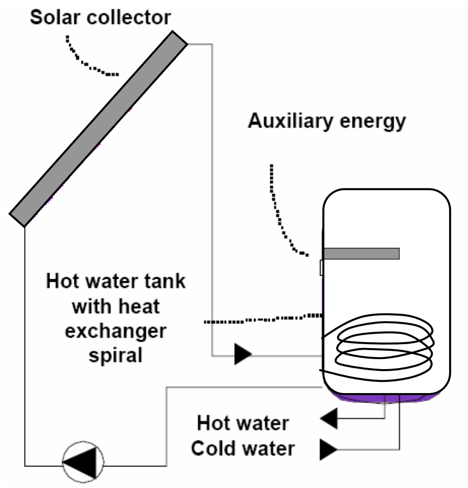
Side effects

Due to the decreased heat loss from the boiler it can be necessary to install radiators in adjacent rooms for heating these. The decrease of temperature in the boiler room will increase the comfort for operational personnel. The risk of burns of the operational personnel is reduced, as the surface temperature of the boiler is reduced.

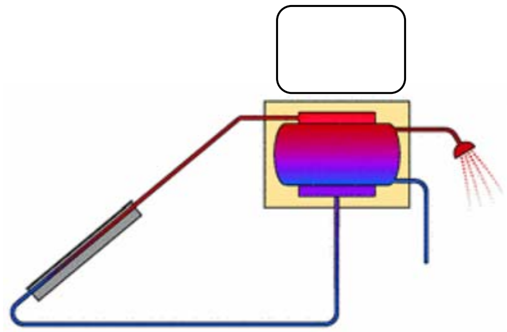
Utility measures - Heat generation

UG 2: Solar collectors - DHW

Basic principle



Type 1: Central and Northern Europe



Type 2: Southern Europe

In a solar collector the water or heat transferring fluid is heated by the sunrays. The highest efficiency rates are achieved by insulating the panel casing well at the back and covering the panel with glass or even better with thermo pane. By applying a special coating to the panel, the rays are absorbed while the warm panel emits only a minor part of heat compared to a normal painted surface.

For Central and Northern Europe the heat is supplied to the hot water tank by circulation of an anti-freeze solution between the hot water tank and the solar collectors.

In Southern Europe where freezing in the solar collectors is not a problem the water from the hot water tank can be circulated directly through the solar collectors. For such systems the hot water tank is placed above the tank which results in natural circulation of the water due to buoyancy without the need for a control system or a pump.

Energy is saved by partial replacement of the need for the primary heat source e.g. the boiler for heating of domestic hot water. A properly sized solar heating system will typically provide up to 60% of the heating consumption for domestic hot water on a yearly basis.

Investment and savings

The values in the table are based on the construction of a solar heating system for production of domestic hot water. The building comprises 50 flats with a domestic hot water consumption of 250 L/m2 p.a. of which the solar heating system will supply 60 % of the necessary heating. The existing oil boiler has an efficiency of 85 %.

Region	Baltic	Central Europe	Southern Europe
Initial investment, I, €/m2	10.8-13.2	8.1-9.9	5.4-6.6
Maintenance cost, M, % of inv p.a.	0.5 %	0.5 %	0.5 %
Labour intensity	Medium	Medium	Medium
Technical Lifetime, n, years	15	15	15
Energy savings, □E, kWh/m2 p.a.	8.3-10.2	8.3-10.2	8.3-10.2
Cost of Saved Energy, CSE ((I+n*M)/(n*□E)), €-cent/kWh	7.6-11.4	5.7-8.5	3.8-5.7

Application

Solar heating systems for production of domestic how water are best suited for buildings in regions with large amount of solar radiation and with:
Limited shadows from surrounding buildings and/or trees.
Large hot water consumption during spring, summer and autumn such as dwellings and sports facilities.
Sufficient and usable roof area.
Short distance from solar collectors to boiler room to minimize circulation losses within the solar heating system.
Other planned renovations of the roof construction or buildings services related to domestic hot water productions such as boilers and hot water tanks. This implies a lower cost of establishment and easier integration with the remaining building services. This also applies for new buildings.

Solar heating systems are not suited for buildings with:
Inexpensive energy back up (e.g. production enterprises)
Limited hot water consumption

Implementation

The implementation of a solar heating system will require the installation of a new hot water tank.

Supervision/Quality assurance

General quality assurance is usually performed for the individual components. The system as a whole should be pressure tested subsequently.

Maintenance

The state of the anti freeze solution and the positive electrode should be checked every 2-3 years. The functionality of the safety valves should be checked with the same interval. The inspection can mostly be performed by non specialists (e.g. the owners/users of the building).

Side effects

Solar collectors will affect the architecture of the building. If this is a focus point, care should be taken to integrate the panels in an appropriate manor. The hot water storage will take up more space.

Connection to DH

Basic principle

Substitution of heat source from a central heating system to district heating supply. The existing boiler is replaced by a heat exchanger which transfers heat from the district heating water to the water in the internal heating system of the building.
Modern heat exchangers have a very low conversion loss and further the price of district heating is in many cases significantly lower than oil. Old oil boilers can have efficiencies as low as 80 % plus a significant heat loss in idle mode.

Investment and savings

Based on existing heat supply being an oil-fired boiler installed in the 1980'es and the presence of a district heating distribution system (main pipe) located 200 meters from the building. The building comprises 50 flats and the heat demand is set to 8 MWh/year per flat in the Baltic region, 7.3 MWh/year in Central Europe and 4.9 MWh/year for Southern Europe.
Shifting fuel from e.g. oil to district heating implies shifting to a cheaper fuel. This is not taken into account in the calculation of the CSE that solely prices the saved energy. Therefore the CSE is not calculated for this measure. Instead the simple payback period and return of investment after 10 years are calculated. For the same reason the heat prices employed in the example are presented.

Region	Baltic	Central Europe	Southern Europe
Oil price, € cent/kWh	9.5	9.0	9.0
Price of district heat, € cent/kWh	5.0	6.0	6.0
Initial investment, I, €/m2	15-30	15-30	8-15
Maintenance cost, M, €/m2 p.a.	0	0	0
Labour intensity	High	High	High
Technical Lifetime, n, years	20	20	20
Energy savings, ΔE, kWh/m2 p.a.	20	20	12
Payback period, years	2-3	3-4	2-3
Return of investment after 10 years, 1,000 €	160-200	95-135	70-90

Application

Especially appropriate if the existing heat supply is an old and ineffective boiler and if there is district heating distribution system established relatively close to the building. The investment depends on the distance from the existing district heating distribution system to the building.

Implementation

It is necessary to do without heat supply in up to two weeks so the replacement of the heating system should be undertaken outside the heating season.

Supervision/Quality assurance

It is important to install heat meters so it can be ensured that the heat output and the supply temperature of the heat exchanger are satisfactory. A pressure test should be performed when the pipe work is finished.

Maintenance

The district heating installation needs very limited maintenance.

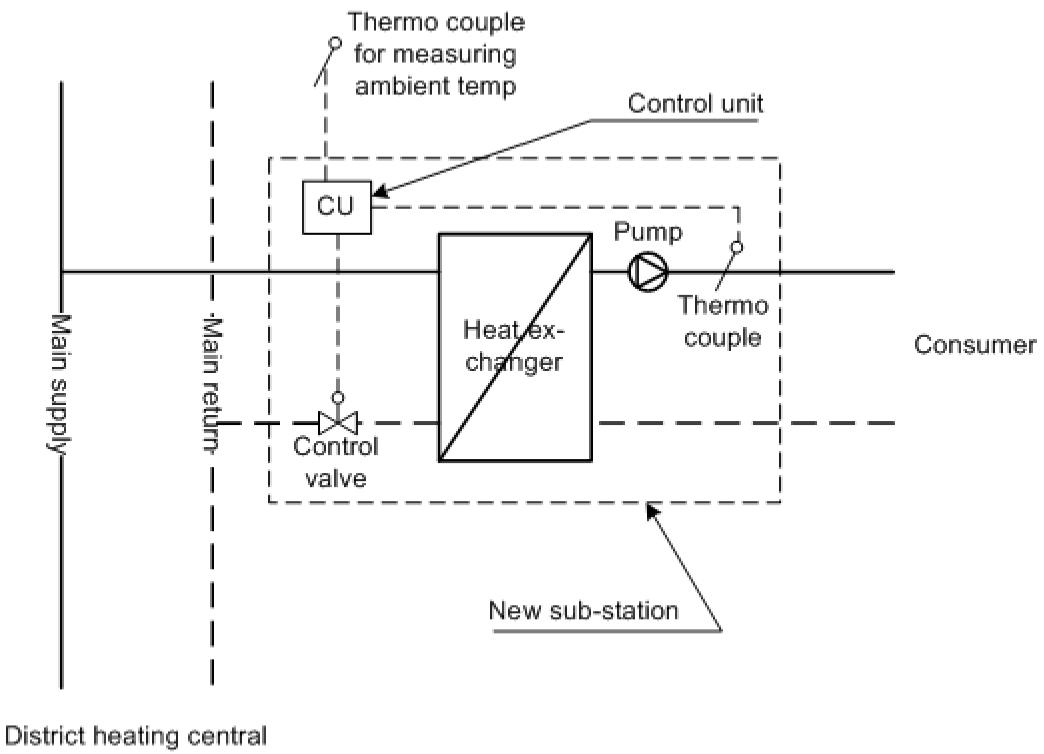
Side effects

In general producing the heat on a larger plant results in decreased emissions (both green house gases and particles) and increased overall efficiency which is even higher if the heat is produced on a combined heat and power plant.

UG 4: New DH sub station

Basic principle

In existing district heating supply systems with a limited number of sub stations the relatively few and large substations supply a large number of heat consumers. This implies a limited possibility to control the heat supply in a satisfying manner. An increased number of substations enable the district heating supplier to control the supply temperature and water flow in a more optimal way. Hereby the total heat loss of the district heating system and the electricity consumption for pumping the district heating water are reduced and thus the total operation costs for supplying district heating is reduced. Other factors being equal this should imply a reduced district heating price for the individual customer.



Regarding economical feasibility there is off course a lower limit for the number of consumers and heat demand for each substation. The level of this lower limit must be individually assessed.

Investment and savings

It is assumed that the savings obtained are transferred to the consumers. The building comprises 50 dwellings and the heat demand is set to 8.0 MWh/year per flat in the Baltic region, 7.3 MWh/year in Central Europe and 4.9 MWh/year for Southern Europe.

Region	Baltic	Central Europe	Southern Europe
Initial investment, I, €/m2	1.9-2.3	1.8-2.2	1.7-2.0
Maintenance cost, M, €/m2 p.a.	0.1	0.1	0.1
Labour intensity	Medium	Medium	Medium
Technical Lifetime, n, years	15	15	15
Energy savings, E, kWh/m2 p.a.	7.2-8.8	6.6-8.0	4.4-5.4
Cost of Saved Energy, CSE ((I+n*M)/(n*E)), €-cent/kWh	2.6-3.6	2.7-3.8	3.8-5.5

Application

The measure can be applied in district heating supply systems with a limited number of district heating substations.

Implementation

Implementation of the new substation requires shutting down the heat supply in a few days (less than a week) and thus the building will have to do without heat during this period.

Supervision/Quality assurance

It is important to install heat meters so it can be ensured that the heat output and the supply temperature of the substation are satisfactory. A pressure test should be performed when the pipe work is finished.

Maintenance

The district heating substation needs limited maintenance.

Side effects

Increasing the number of substations enable the district heating supplier to enforce non-payment procedures more efficiently. Also more accurate metering will be possible.

UG 5: New biomass fired boiler

Basic principle

Replacing the existing boiler with a biomass fired boiler. If the existing heat producing plant is an old in-effective fossil fuel fired boiler there is both an energy saving potential due the higher efficiency of the new boiler and an economical saving potential as biomass often is significantly cheaper than fossil fuels.

Depending on the size of the plant different fuels are relevant; for small plants wood pellets are the obvious choice whereas for larger plants a larger variety of fuels can be utilized e.g. straw, wood chips etc.

Investment and savings

The values in the table are based on the replacing an individual oil-fired boiler installed in the 1980's with a new wood pellet fired boiler. The price of biomass price can vary extremely and it is not possible to state a reasonable average price within the three regions. For this example the price of the biomass is set to 40 €/MWh for the Baltic region and 50 €/MWh for Central and Southern Europe. The building comprises 50 flats and the heat demand is set to 8.0 MWh/year per flat in the Baltic region, 7.3 MWh/year in Central Europe and 4.9 MWh/year in Southern Europe. Shifting fuel from e.g. oil to biomass implies shifting to a cheaper fuel. This is not taken into account in the calculation of the CSE that solely prices the saved energy. Therefore the CSE is not calculated for this measure. Instead the simple payback period and return of investment after 10 years are calculated. For the same reason the heat prices employed in the example are presented.

Region	Baltic Region	Central Europe	Southern Europe
Oil price, €-cent/kWh	9.5	9.0	9.0
Price of biomass, €-cent/kWh	4.0	5.0	5.0
Initial investment, I, €/m2	15-30	15-30	8-15
Maintenance cost, M, €/m2 p.a.	0.5	0.5	0.4
Labour intensity	Low	Low	Low
Technical Lifetime, n, years	20	20	20
Energy savings, ΔE, kWh/m2 p.a.	20	20	13
Payback period, years	1-3	2-4	1-3
Return of investment after 10 years, 1,000 €	200-240	140-175	90-110

Application

Applicable to all kinds of buildings. Especially appropriate if the existing heat supply is an old and ineffective boiler and if there is cheap and plenty biomass available in the region.

As the investment is quite high it is recommended to employ a consultant to undertake a proper feasibility study.

Implementation

It is necessary to do without heat supply in up to two weeks so the replacement of the heating system should be undertaken outside the heating season.

Supervision/Quality assurance

The performance data of the plant shall be measured and documented in order to compare these to the performance data guarantied by the supplier. These include:

Heat output
Supply temperature
Efficiency from fuel to heat (measurements of fuel consumption and heat output)
Degree of modulation (how low load can the boiler be operated at and at which efficiency)
Emissions (NOx, SOx and particles).

Maintenance

During the first six months after installation there will be some degree of commissioning. Subsequent yearly revisions are recommended.

Further, biomass is a more complicated fuel than e.g. oil or natural gas and so the extent of maintenance is higher for a biomass-fired boiler compared to an oil-fired or a natural gas-fired boiler.

Side effects	Sheet 3 of 3
Depending on the choice of biomass there is a varying content of ash in the fuel. This ash needs to be emptied out of the ash container of the plant. Depending on the size of the ash container and the chosen biomass fuel this needs to be done as often as once every week, but normally less frequently. Some biomass fuels contain more than insignificant quantities of heavy metals which will remain in the ashes. Regulations may exist for safe depositing of this residue. However, biomass is a renewable energy source causing no CO2-emissions when converted to heat and hot water.	

Utility measures - Heat generation

UG 6: New boiler, fired with other than biomass

Basic principle

Replacing the existing boiler with a new and more efficient boiler. If biomass is excluded there is the choice of an oil fired or a natural gas fired boiler to replace the existing heat supply. New condensing oil boilers have an efficiency of more than 95 % whereas condensing natural gas boilers have efficiencies up to app. 105-110 % (both based on lower heating value). The lower the existing boiler's efficiency; the higher the energy and economical saving potential.

Investment and savings

The values in the table are based on the replacement of an individual oil fired boiler installed in the 1980's with a new oil fired boiler. The building comprises 50 flats and the heat demand is set to 8 MWh/year per flat in the Baltic region and Central Europe and 5 MWh/year for Southern Europe.

Region	Baltic Region	Central Europe	Southern Europe
Oil price, € cent/kWh	9.5	9.0	9.0
Initial investment, I, €/m2	7-13	6-12	4-8
Maintenance cost, M, % of inv. p.a.	0.5	0.5	0.5
Labour intensity	Low	Low	Low
Technical Lifetime, n, years	20	20	20
Energy savings, □E, kWh/m2 p.a.	20	18	13
Cost of Saved Energy, CSE ((I+n*M)/(n*□E)), €-cent/kWh	4-6	4-6	3-4
Payback period, years	3-6	3-6	2-4
Return of investment after 10 years, 1,000 €	24-38	17-30	15-19

Application

Applicable to all kinds of buildings. Especially appropriate if the existing heat supply is an old and ineffective boiler. For shifting to a natural gas fired boiler a natural gas distribution system has to be in place in the neighbourhood where the building is located.

Implementation

Implementation of the new boiler requires shutting down the heat supply in a few days (less than a week) and thus the building will have to do without heat during this period.

It is recommended to employ a consultant to undertake a proper feasibility study.

Supervision/Quality assurance

Subsequently the following operation parameters needs to be tested:

Temperature of combustion air
Temperature of flue gas
Soot level in flue gas
Oxygen level in flue gas
Carbon monoxide level in flue gas (solely for boilers with blue flame burners).

Maintenance

There may be a limited extent of balancing the first six months after installation. Subsequent yearly revisions are recommended.

Side effects

Reduced need for maintenance.

UG 7: Replacement of burner in boiler

Basic principle

Replacement of existing burner in oil and natural gas boilers with new and more efficient burners.

In the burner the oil is mixed with combustion air, ignited and combusted (converted to hot flue gas). The hot flue gas is used in the boiler to heat the water before it is lead to the chimney. By employing new burners a more efficient and cleaner combustion is achieved.

By installing a modern burner the loss due to through draft is also minimized as dampers are an integrated part of a modern burner.

In addition to a potential energy saving it also implies a reduced emission of particles and unburned fuel and additionally reduced maintenance. Further, the new burner allows the boiler to operate more efficiently at low loads.

In general blue flame burners are recommended for oil fired boilers.

Investment and savings

The values in the table are based on the replacement of the burner in an individual natural gas fired boiler installed in the 1980's with a new burner. The boiler supplies a building that comprises 50 flats. The heat demand is set to 8 MWh/year per flat in the Baltic region and Central Europe and 5 MWh/year for Southern Europe.

Region	Baltic Region	Central Europe	Southern Europe
Initial investment, I, €/m2	0.3	0.3	0.2
Maintenance cost, M, €/m2 p.a.	0	0	0
Labour intensity	Low	Low	Low
Technical Lifetime, n, years	10	10	10
Energy savings, ΔE, kWh/m2 p.a.	10	10	6
Cost of Saved Energy, CSE ((I+n*M)/(n*ΔE)), €-cent/kWh	5	5.5	7

Application

Can be applied to all old oil or natural gas fired boilers.

Implementation

It is necessary to do without heat supply in one to two days so the replacement of the burner should be undertaken outside the heating season.

Supervision/Quality assurance

The following operation parameters needs to be tested subsequent to installation:

Temperature of combustion air
Temperature of flue gas
Soot level in flue gas (solely for oil fired boilers)
Oxygen level in flue gas
Carbon monoxide level in flue gas.

Maintenance

The maintenance is significantly reduced by installing a new burner that ensures a cleaner combustion.

Side effects

Reduced maintenance, reduced emissions of unburned fuel and particles (for oil fired boilers).

3.3 Reduction of losses from the heat distribution system

To ensure that the energy produced is utilized only for the intended purposes, undesirable losses from the distribution systems should be reduced to a minimum.

The measures described in this section include, among others, insulation of pipes and ducts, controlling temperatures and heat recovery.

UD 1: Regulation of room temperature using radiator thermostats

Basic principle

A radiator thermostat consists of a regulation valve controlled by an air or liquid filled thermostat. The thermostat can be mounted directly on the valve or connected to this by a thin bendable cobber tube, so the thermostat can be placed where it registers the correct temperature.

The thermostat has a scale for adjustment of the desired room temperature. The valve is placed so it controls the water flow through the radiator, i.e. the radiator thermostat controls the radiator's heat output. When the room temperature is approximately 1° C higher than desired value the valve will be shut off and when the room temperature is correspondingly lower than desired the valve will be fully open. By this the room temperature is kept closer to the desired room temperature compared to normal hand regulated radiator valves.

The energy saving can be obtained by:

Lowering of average room temperature

Utilization of the internal and external heat gains from persons, lighting, sun etc. which results in a decrease of the heat output of the radiators

It is of great significance for the amount of savings that when selecting radiator thermostats it is ensured that:

The quality of the radiator thermostat is high. This will among other things mean that the position of the valve is practically the same for a given temperature regardless of the whether the temperature has been increasing or decreasing (the deviation is called hysteresis).

Correct dimensioning depending on the pressure and water flow in the heating system when selecting valve size.

For each room the thermostat is placed so the room temperature can be measured as correctly as possible. The thermostat directly mounted on the radiator valve is often adequate; however a remote sensor placed e.g. on the wall is to be preferred, e.g. if the valve is cover by a curtain.

The plant is balanced so the desired water distribution is maintained even for fully open radiator valves.

Investment and savings

The values in the table are based on the installation of radiator thermostats for regulation of the room temperature. The building comprises 50 flats and the heat demand is set to 8 MWh/year per flat in the Baltic region and Central Europe and 5 MWh/year for Southern Europe. It is estimated that the energy savings obtained by 1) and 2) leads to reductions of the heat consumption by respectively 6-7 % and 8-20 %.

Region	Baltic Region	Central Europe	Southern Europe
Initial investment, I, €/m2	1.65	1.65	1.65
Maintenance cost, M, €/m2 p.a.	0.5% p.a. of the initial investment		
Labour intensity	medium	medium	medium
Technical Lifetime, n, years	10	10	10
Energy savings, □E, kWh/m2 p.a.	10-32	10-32	6-20
Cost of Saved Energy, CSE ((I+n*M)/(n*□E)), €-cent/kWh	1.8-5.7	1.8-5.7	17.4-58

Application

Can be applied in all building categories where water is used as heat conducting fluid in the heating system.

Implementation

The measure can be undertaken in periods where the building can do without heat supply during the installation period.

Supervision/Quality assurance

The work can be inspected on site.

Maintenance	**Sheet 3 of 3**

The most important maintenance is replacement of the bushing of the radiator valves which normally can be replaced by the janitor. If high quality thermostats are applied the annual maintenance is not likely to exceed 1 % of the investment.

Side effects

Maintaining the same usage patterns as prior to the installation of thermostats can lead to increased energy consumption.
This can be avoided by efficient information to the users of the building and limitation of the manual regulation on the radiator valves.

If the heating plant is provided with a timer for lowering of temperature at night two conditions need to be addressed:

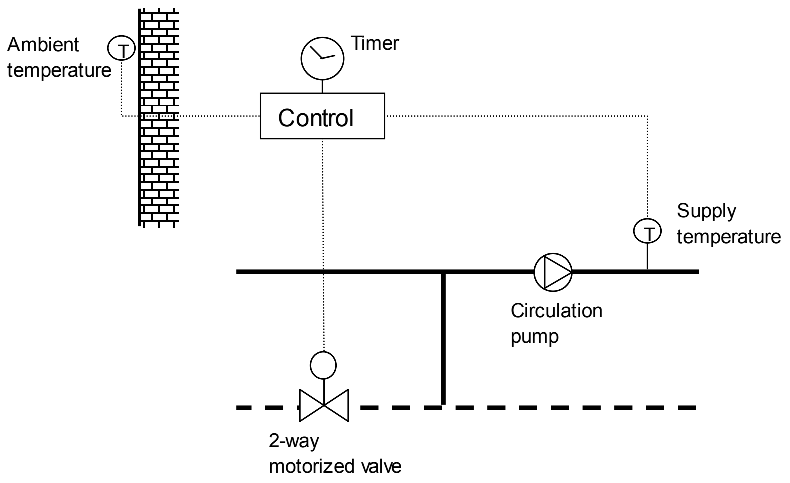
The lowering of the supply temperature when the building is not in use needs to be so extreme (app. 20-40° C) that the radiator thermostats cannot abate the effect by automatic opening of the radiator valves.

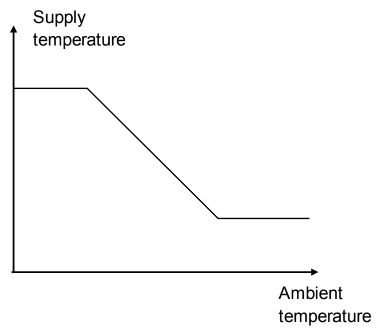
If the heat systems piping is not correctly balanced by the use of zone balancing valves there is a risk that some radiators will take so much heat from the circulated water that others is supplied with too little and thus some rooms will be heated slower than others

This can be prevented by balancing the heat supply system and ensuring an adequate hydraulic resistance in the radiator valves (typically between 5 and 10 kPa).

UD 2: Ambient temperature dependent supply regulation

Basic principle





This measure aims at compensating for the effects of the ambient conditions on the indoor environment of the building by regulating the supply temperature of the water used in the radiator system. The temperature regulation is done by shunting the cooled return water into the hot supply water from the boiler or the district heating grid.

The ambient temperature is measured with an outside temperature gauge which via a control panel and a regulation valve controls the supply temperature according to a defined regulation strategy.
The supply temperature is measured with a temperature gauge placed in the supply pipe just downstream of the circulation pump.

The relation between the ambient temperature and the supply temperature is to be set individually according to the specific building and its needs. The adjustment to the individual building is done on an estimated basis at first, followed by a final adjustment during the entire heating season.

Reducing the supply temperature outside the time of use of the building can also lead to energy savings.

The energy saving is achieved by:

Automatically adjusting the supply temperature to the present demand, thereby reducing losses and overheating of the building.
Reducing the supply temperature outside the time of use.

Investment and savings

Control systems can be obtained in many quality and price ranges depending on capacity, sensitivity etc. The present economical calculations will consequently be indicative only. The values in the table are based on the installation of ambient temperature dependent supply regulation. The building comprises 50 flats and the heat demand is set to 8 MWh/year per flat in the Baltic region and Central Europe and 5 MWh/year for Southern Europe. It is estimated that the energy saving obtained by 1) leads to reductions of the heat consumption by approximately 10% and the energy saving obtained by 2) leads to reductions of the heat consumption by up to 25%.

Region	Baltic Region	Central Europe	Southern Europe
Initial investment, I, €/m2	1	1	1
Maintenance cost, M, €/m2 p.a.	1% p.a. of the initial investment		
Labour intensity	medium	medium	medium
Technical Lifetime, n, years	10	10	10
Energy savings, ΔE, kWh/m2 p.a.	16-40	16-40	10-25
Cost of Saved Energy, CSE ((I+n*M)/(n*ΔE)), €-cent/kWh	0.3-0.7	0.3-0.7	0.4-1.1

Application

Automatic supply temperature control dependant on ambient temperature can be applied to all type of building categories where water is used as heat conducting fluid.

Periodically reduction of the supply temperature can be implemented in buildings which are not in use during weekends and holidays.

Adequate circulation and return temperature to the boiler shall be ensured. These temperatures depend on the individual boiler.

Implementation

The location of the outside temperature gauge is important. If the regulation of the heating plant is not divided according to the orientation of the façades, the best location of the temperature gauge is on the north façade of the building or on the north-eastern corner. The largest savings and the most efficient regulation of the indoor temperature are obtained when the heating plant is divided according to the main façades. In this case the outside temperature gauge is placed on the relevant façade and therefore the regulation system can obtain the best data regarding temperature, wind and sun conditions which is required for the regulation.

It is necessary to do without heat supply during installation of temperature gauges and to establish a shunt arrangement, if not already existing.

Supervision/Quality assurance

The pipe work shall be pressure tested subsequent to installation.

The key point for achieving the maximum energy saving is the correct adjustment of the relation between the ambient temperature and the supply temperature.

Maintenance

The technical staff or janitor must be thoroughly instructed in the functionality and setting options of the control system.

Individual timers for reduction of temperature will have to be checked periodically for correct time. This should at a minimum be done in connection with change from winter- to summer-time and vice versa.

For periodically reduction of the supply temperature two conditions need to be addressed:

The lowering of the supply temperature when the building is not in use needs to be so extreme (app. 20-40° C) that the radiator thermostats cannot abate the effect by automatic opening of the radiator valves.

If the heat systems piping is not correctly balanced by the use of zone balancing valves there is a risk that some radiators will take so much heat from the circulated water that others is supplied with too little and thus some rooms will be heated slower than others.

This can be prevented by balancing the heat supply system and ensuring an adequate hydraulic resistance in the radiator valves (typically between 5 and 10 kPa).

Balancing of heat system

Basic principle

A correctly functioning heat system requires a thorough initial balancing. The balancing ensures that each individual heat supplier (e.g. radiators) receives the correct flow of water according to the calculations. The water flow must be just adequate in order to obtain the desired room temperature when the radiator valves are fully open.

Many systems are inadequately balanced. Lack of balancing results in uneven heat distribution and the undesirable temperature differences is often rectified by increasing the supply temperature and adjusted to the demand in the rooms with the lowest temperature. This implies that the temperature in the other rooms in the building will be too high. As it can be difficult to regulate the heat output from radiators etc. in the individual rooms the problem is often solved by airing. The high room temperature combined with the airing results in unnecessary high energy consumption.

Balanced systems can be unbalanced in relation to re-insulation; i.e. insulation of roofs. In order to obtain the full benefit of the re-insulation this should be followed by a re-balancing of the heat system.
Some systems lack the option of balancing totally or partly and for these a scheme for installation and setting of the necessary balancing valves and possibly replacement of all radiator valves will be required.

The energy saving that can be achieved by balancing depends to a large extent of the system's age and technical level. The saving can be up to 30 %; however a valuation of the actual saving shall be included in a preliminary investigation.

Investment and savings

The values in the table are based on balancing of the heating system in a building which comprises 50 flats. The heat demand is set to 8 MWh/year per flat in the Baltic region and Central Europe and 5 MWh/year for Southern Europe. It is estimated that the energy saving obtained by balancing the heating system in the building leads to reductions of the heat consumption by approximately 10-15 %. The technical life time equals the same as the rest of the heating system; in this case 20 years.

Region	Baltic Region	Central Europe	Southern Europe
Initial investment, I, €/m2	1	1	1
Maintenance cost, M, €/m2 p.a.	0.5% p.a. of the initial investment		
Labour intensity	medium	medium	medium
Technical Lifetime, n, years	20	20	20
Energy savings, □E, kWh/m2 p.a.	16-40	16-40	10-25
Cost of Saved Energy, CSE ((I+n*M)/(n*□E)), €-cent/kWh	0.1-0.3	0.1-0.3	0.2-0.6

Application

This measure is applicable in all buildings where a technical investigation shows it is beneficial.

Implementation

The balancing should be carried out during the heating period and the supply temperature should be decreased to ensure all radiator valves is fully opened.
If there are no existing balancing valves, these can be installed during periods where the building can do without heat supply.

Supervision/Quality assurance

The work can be inspected by spot tests onsite.

Maintenance

No specific maintenance requirements are related to this measure. Possible replacement of bushings and fittings occurs very rarely.

Side effects

Balancing implies no undesirable side effects; on the contrary an improved regulation and comfort and decreased noise from the installations.

UD 4: Extra insulation of hot piping

Basic principle

The energy saving is obtained by extra insulation of hot piping to reduce the heat loss from the piping.

The energy saving is largest in systems with:

Zone division (many pipes in small dimensions)

High water temperature in pipes (large temperature difference between pipe surface and surroundings)

Un-insulated fittings (taps, valves flanges etc.)

Many pipes placed in unheated rooms (basements, spaces under roof slopes etc.)

Lack of automation and unbalanced systems

Investment and savings

The values in the table are based on extra insulation of a hot piping with a diameter of 32 mm. The insulation thickness is increased from 15mm to 60mm. The temperature of the water in the pipe is 70° C and the ambient temperature is 20° C. The heat loss from the pipe before applying the extra insulation is 19 W pr. m pipe and 9 W pr. m pipe after applying the insulation. Hence the heat loss is reduced by 10 W pr. m. The energy savings obtained by applying extra insulation to hot piping occur outside the heating season.

Region	Baltic Region	Central Europe	Southern Europe
Days outside the heating season	120	150	240
Initial investment, I, €/m-pipe	25	25	25
Maintenance cost, M, €/m-pipe p.a.	0.5 % p.a. of the initial investment		
Labour intensity	medium	medium	medium
Technical Lifetime, n, years	20	20	20
Energy savings, □E, kWh/m-pipe p.a.	28	35	57
Cost of Saved Energy, CSE ((I+n*M)/(n*□E)), €-cent/kWh	4.8	3.9	2.4

Application

Extra insulation of hot piping can be implemented in all categories of buildings with pipes for hot water and heating systems.

Implementation

Normally, the work can be implemented while the heat system is in operation.

Supervision/Quality assurance

The work can be inspected by spot tests of thickness and quality of insulation.

Maintenance

The technical staff shall be instructed to periodically inspect the insulation as water from leakages in fittings can leak into the insulation layer causing decreased insulation.

Side effects

Extra insulation of the hot piping can require installation of radiators in rooms which previously were heated by the heat loss from pipes.

UD 5: Heat cost allocators

Basic principle

Heat allocators are mounted on the radiator to indicate the energy consumption of the radiator. By installing allocators on all radiators in the building, the total energy bill can be divided between the tenants.

The simple version consists of a glass tube with a liquid which evaporate in accordance with the heat output of the radiator (left figure). A electronic type is operated by a small battery cell and measures the surface temperature of the radiator (right figure). In addition to that, some types also measure the room temperature to determine the heat output more accurately.

The electronic type can also be equipped with a radio transmitter to avoid access to the premises for manual read-off.

By installation of radiator meters, the user becomes aware of the heating consumption. Experience shows that increased awareness with respect to energy consumption generally leads to a more energy efficient behaviour of the user and thereby indirectly to energy savings.

Investment and savings

The values in the table are based on the installation of radiator meters for all rooms in an apartment building. The building comprises 50 flats and the heat demand is set to 8 MWh/year per flat in the Baltic region and Central Europe and 5 MWh/year for Southern Europe. It is estimated that installation of radiator meters leads to a reduction of heat consumption by 10 %.

Region	Baltic Region	Central Europe	Southern Europe
Initial investment, I, €/m2	0.66	0.66	0.66
Maintenance cost, M, €/m2 p.a.	0.5 % p.a. of the initial investment		
Labour intensity	Low	Low	Low
Technical Lifetime, n, years	10	10	10
Energy savings, □E, kWh/m2 p.a.	16	16	10
Cost of Saved Energy, CSE ((I+n*M)/(n*□E)), €-cent/kWh	0.4	0.4	0.7

Application

The measures can be applied for all buildings where water is used as heat conducting fluid.

Implementation

The installation of the meters will not cause interruptions of the operation of the heating system.

Supervision/Quality assurance

The meters need to be read just after installation and subsequently once a year for division of the energy bill.

Maintenance

The evaporative version requires change of glass tube in connection with the annual reading. Electronic types require new batteries at intervals depending of type and manufacture.

Side effects	
There are no side effects.	

Utility measures - ventilation

UV 1: Periodical operation of ventilation systems

Basic principle

The ventilation system can often be stopped when the building is not in use.

Periodical operation can be controlled by a building management system or by individual synchronised timers.

The energy savings are achieved by reducing the energy consumption in the following fields:

The heating of fresh air
Operation of the fan motor
Operation of a humidifier if any
Operation of a cooling system if any

The energy savings which can be achieved depends on the size of the fresh air renewal rate and the size of the air circulation.

Investment and savings

The values in the table are based on periodical operation of a mechanical ventilation system without moistening and cooling. The ventilation system has a flow rate of 1,000 m3/h and the operational time is reduced from constant operation to 60 hours a week. The energy saving and CSE for a ventilation system with a heat recovery unit of 65 % is given in parenthesis.

Region	Baltic Region	Central Europe	Southern Europe
Initial investment, I, €/m3	0.17	0.17	0.17
Maintenance cost, M, €/m3 p.a.	0.5% p.a. of the initial investment		
Labour intensity	low	low	low
Technical Lifetime, n, years	10	10	10
Energy savings, ΔE, kWh/m3 p.a.	29 (12)	26 (11)	19 (9)
Cost of Saved Energy, CSE ((I+n*M)/(n*ΔE)), €-cent/kWh	0.06 (0.14)	0.07 (0.15)	0.09 (0.19)

Application

The measure can be applied in all building categories that have mechanical ventilation and a limited time of use.

Implementation

The installation can be carried out without any inconvenience for the users of the building.

Supervision/Quality assurance

The result of the installation can be checked on the spot by doing a performance test.

Maintenance

Individual timers will have to be checked periodically for correct time. This should at a minimum be done in connection with change from winter- to summer-time and vice versa.

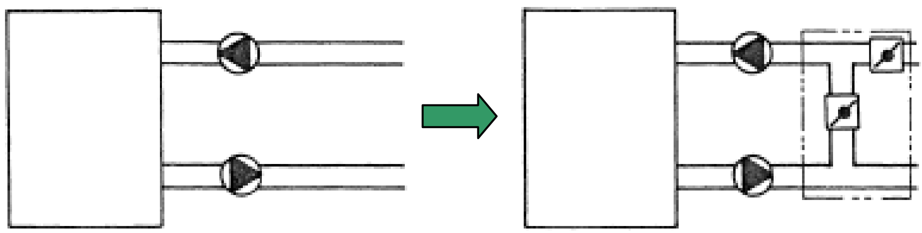
The annual maintenance costs for renewal are estimated to be 2-5% of the initial investment.

Side effects

Subsequent to the implementation some complaints may occur from the users who use the building outside normal operation hours. This can be countered by installing timer switches which enables the users to extent the operation time of the ventilation system, e.g. for an hour at the time.

UV 2: Recirculation in mechanical ventilation systems

Basic principle



If the ventilation system is used for heating of the building, it may not be necessary to heat the full amount of circulated air.

Unless the air is contaminated, e.g. by tobacco smoke, it will be possible to recirculate some of the air. Otherwise a heat exchanger will have to be installed to recover the energy from the exhaust air, see UV 4 for details.

When implementing recirculation, a part of the exhaust air is mixed with the fresh air. The energy savings are achieved because a smaller amount of fresh air needs to be heated.

Investment and savings

The values in the table are based on recirculation of air in a mechanical ventilation system. The ventilation system has a flow rate of 1000 m3/h during all hours a week and the recirculation of air is increased from 0 % to 50 %. The energy saving and the CSE for a ventilation system with a heat recovery unit of 65 % is given in parenthesis.

Region	Baltic Region	Central Europe	Southern Europe
Initial investment, I, €/m2	1.65	1.65	1.65
Maintenance cost, M, €/m2 p.a.	0.5% p.a. of the initial cost		
Labour intensity	medium	medium	medium
Technical Lifetime, n, years	10	10	10
Energy savings, □E, kWh/m2 p.a.	19 (7)	17 (6)	11 (4)
Cost of Saved Energy, CSE ((I+n*M)/(n*□E)), €-cent/kWh	0.9 (2.6)	1.0 (2.9)	1.5 (4.3)

Application

Recirculation can be used in administration buildings, schools, nursing homes etc., but should not be used in buildings where the exhaust air contains particles that can damage your health, a lot of moisture or air that can result in bad smells.

Implementation

The measure can normally be carried out without having to stop the system for a long time.

Supervision/Quality assurance

The performance can be checked on site.

Maintenance

The air dampers need to be inspected periodically but other than that, no maintenance is necessary other than the maintenance that was already required for the ventilation system.

Side effects

If the quantity of the fresh air is greatly reduced, the quality of the air will be reduced.
It will be possible to experiment with different degrees of recirculation, by changing the adjustment of the air dampers.

Utility measures - ventilation

UV 3: Extra insulation of the ventilation ducts

Basic principle

The energy savings are achieved by insulating the ducts so that the undesired heat loss/ cooling loss to the surroundings are reduced. The energy saving is largest for systems with:

ducts divided into zones (many canals in small dimensions)
high/ low inlet temperature compared to the surroundings.

Investment and savings

The values in the table are based on extra insulation of a ventilation duct with a diameter of 200 mm. The insulation thickness is increased from 20 mm to 40 mm. The temperature of the air in the duct is 30° C and the ambient temperature is 20° C. The heat loss from the pipe before applying the extra insulation is 12 W pr. m pipe and 7 W pr. m pipe after applying the insulation; hence the heat loss is reduced by 5 W pr. m. The ventilation system is operated during all hours a week however only outside the heating season energy savings are obtained.

Region	Baltic Region	Central Europe	Southern Europe
Days outside the heating season	120	150	240
Initial investment, I, €/m-duct	50	50	50
Maintenance cost, M, €/m-duct p.a.	0.5 % p.a. of the initial investment		
Labour intensity	medium	medium	medium
Technical Lifetime, n, years	20	20	20
Energy savings, □E, kWh/m-duct p.a.	14	17	27
Cost of Saved Energy, CSE ((I+n*M)/(n*□E)), €-cent/kWh	19.9	15.9	10

Application

Extra insulation of the ducts can be applied in all building categories where the ventilation system is used for heating and cooling the building.

Implementation

The work can be carried out while the system is in use.

For ducts in occupied rooms, e.g. above suspended ceilings in offices, the work can cause some inconveniences for the occupants.

Supervision/Quality assurance

The quality of the finished work can be checked by spot tests of the insulation thickness and quality.

Maintenance

The janitor is to be instructed about a periodical inspection of the insulation because moisture or other damage of the insulation will reduce the insulation quality.

Side effects

Insulation of ducts will increase the space requirements. In case the ventilation system is used for cooling during the summer any extra insulation of the ducts will be effective in maintaining the temperature of the air low though the duct system.

UV 4: Heat recovery from exhaust air

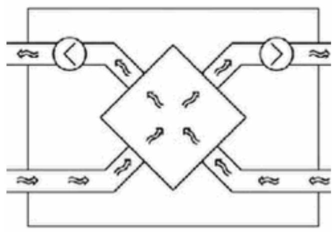
Basic principle

By recovering heat from exhaust air, some of the energy is transferred from the warm exhaust to the cold inlet air. The heat transfer takes place in a heat exchanger without mixing the contaminated indoor air with the fresh outdoor air.

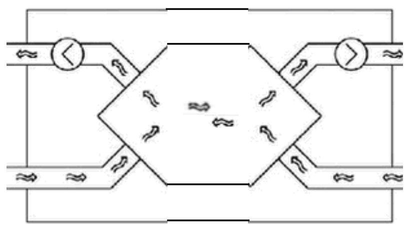
Energy is saved by reduction of energy to heat the outdoor air, as the heat exchanger will preheat the air to a temperature closer to the desired inlet temperature. The largest energy savings will be achieved in cold climates and for buildings with large ventilation requirement, as here is the largest energy consumption for heating of fresh air. Also, the operation time of the ventilation system has a crucial impact on the payback time.

Several different heat recovery systems can be applied, each with different drawbacks and advantages.
The 5 main systems are:

1. Cross flow heat exchanger
The inlet air is lead between rows of thin metal plates placed next to each other. The exhaust air is lead through gaps on the other side of the plates, thus transferring some of the heat to the inlet air. This type can recover up to 70 % of the energy from the exhaust air. As there are no moving parts, it is robust and relatively cheap.

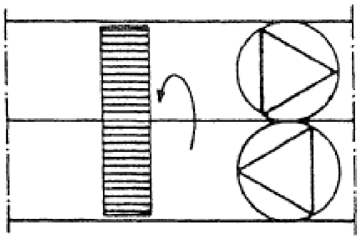


2. Counter flow heat exchanger
This type is a further development of the cross flow exchanger. Here, the two air flows against each other in a counter flow, which makes the transfer of heat more efficient. It takes up a little more space than the cross flow exchanger, but can recover up to 85 % of the energy from the exhaust air.



3. Rotating heat exchanger

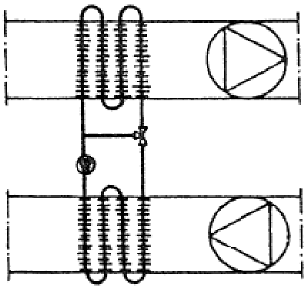
This heat recovery system consists of a circular rotating heat recovery disc. The disc is made of many tiny ducts which can absorb the heat from the exhaust air and release it to the inlet air, when the disc rotates into the inlet duct. The heat recovery can be regulated by changing the rotating speed of the disc. The typical speed is 5-15 rotations per minute.



This type can recover up to 90 % of the energy from the exhaust air. As the disc rotates between the two ducts, there will be a small leakage of air from one duct to the other. The fans should be installed in such a way that the leakage does not introduce contaminated air back into the building.

4. Indirect heat exchanger

The heat recovery principle consists of a cooling surface placed in the exhaust duct and a heating surface placed in the inlet duct. A pump circulates a fluid between the two surfaces, thus transferring heat from the exhaust to the inlet air. The heat recovery can be regulated by reducing the flow through the heating or cooling surface. Instead of a 3-way valve as shown in the figure, a variable speed pump can be used for this purpose.

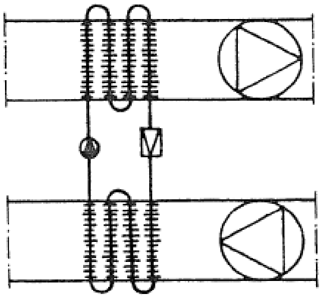


This type can only recover up to 60 % of the energy from the exhaust air, but it can be installed in existing systems, where the inlet and exhaust ducts are not situated next to each other.

5. Heat pump

In principle it is working like a cooling system with the evaporator placed in the exhaust duct and the condenser placed in the inlet duct. The heat pump is able to transport heat from a lower to a higher temperature level by adding more energy.

In summertime the function can be changed, so the system can be used for cooling the inlet air.



Investment and savings

The values in the table are based on applying a heat recovery unit with an efficiency of 65 % to a ventilation system. The ventilation system has a flow rate of 1000 m3/h and system is operated all hours a week.

Region	Baltic Region	Central Europe	Southern Europe
Initial investment, I, €/m3	3.7	3.7	3.7
Maintenance cost, M, €/m3 p.a.	1 % p.a. of the initial investment		
Labour intensity	medium	medium	medium
Technical Lifetime, n, years	20	20	20
Energy savings, ΔE, kWh/m3 p.a.	25	22	15
Cost of Saved Energy, CSE ((I+n*M)/(n*ΔE)), €-cent/kWh	0.9	1.0	1.5

Application

Heat recovery can be used in all building categories where a balanced ventilation system is installed.

Implementation

The ventilation system will have to be turned off for 2-14 days during implementation.

Supervision/Quality assurance

The efficiency of the heat exchanger should be verified by measurements.

Maintenance

The filters and heat exchangers needs to be cleaned regularly since dirt on the surfaces will reduce the energy savings significantly.

Side effects

There will be an increase in the ventilation system’s pressure loss.

3.4 Utility measures - cooling

Cooling of buildings is very energy consuming and it is therefore of utmost importance that machinery used for cooling is as efficient as possible and that undesirable losses are reduced to a minimum.

Utility measures - cooling

UC 1: New cooling unit - increasing COP

Basic principle

By replacing existing cooling plant with a new cooling plant with a higher efficiency. The Coefficient of Performance (COP) for modern cooling plants can be more than two times higher than old cooling plants. Based on this the cooling demand for e.g. an air conditioning system can be satisfied by consuming half of the power by replacing the cooling plant. In order to obtain the highest possible COP the following general guidelines should be followed:

Lowest possible condensing temperature
Highest possible evaporating temperature
Minimize the pressure drop in the refrigeration distribution system.

It is off course a question of identifying the optimal solution from an economical point of view. In order to do this the installation costs versus the operational costs are to be investigated. It is recommended to have a technical consultant undertake a thorough assessment in order to obtain the most efficient cooling plant.

Investment and savings

Region	Baltic Region	Central Europe	Southern Europe
Initial investment, I, €/m2	85-103	102-124	119-145
Maintenance cost, M, €/m2 p.a.	0.8-1.0	1.0-1.2	1.2-1.4
Labour intensity	Low	Low	Low
Technical Lifetime, n, years	15	15	15
Energy savings, ΔE, kWh/m2 p.a.	84-102	115-140	229-280
Cost of Saved Energy, CSE ((I+n*M)/(n*ΔE)), €-cent/kWh	6.3-9.5	5.6-8.3	3.2-4.8

Application

The measure applies to all buildings that have an old cooling plant with a low COP. The higher the cooling demand is the higher is the potential economical and energy savings.

Implementation

Normally, implementation of the new cooling unit requires shutting down the cooling supply in a few days (less than a week) and thus the building will have to do without cooling during this period. For more radical changes in the total cooling system (e.g. replacement of piping etc.) this period can be prolonged.

Supervision/Quality assurance

By commissioning, it shall be secured that all temperatures and flows are satisfactory compared to the design parameters.

Maintenance

There may be a limited extent of balancing the first six months after installation. Subsequent yearly revisions are recommended.

Side effects

By changing to a cooling plant employing a natural refrigerant ozone layer depletion and global warming effects are reduced.

3.5 Utility measures - water for domestic use

As the insulation standard of building are improved, the energy consumption by domestic hot water consumption accounts for a larger and larger fraction of the total energy consumption of the building. This applies in particular to residential buildings and hotels whereas administrative building and most public building have relatively small hot water consumption.

Some of the measures described in this section do not directly reduce the energy consumed. However, they can improve the efficiency of the district heating system by returning the water at a lower temperature to the district heating plant.

Utility measures - water for domestic use

UDW 1: Limitation of the draw-off capacity at the taps

Basic principle

For some types of taps, such as shower and wash basin taps, the hot water consumption is proportional to the time, the taps are open.

Energy savings can be achieved by reducing the maximum draw-off capacity and thereby reducing the energy consumption for heating hot water. It is possible to make savings up to 40%. In addition to this there will be savings from the water consumption.

Several manufacturers market faucets with water saving features. This include limitation of draw-off, only to be superseded by pushing a button, single lever faucets, where the centre position provides only cold water etc. The limitation can also be done for existing taps by fitting discs with reduced holes before the taps or by adjusting the throttle valve at each tap.

Investment and savings

The building comprises 50 flats with a domestic hot water consumption of 250 L/m2 p.a. The figures in the table are based on the heat being produced by an oil fired boiler with an efficiency of 85 %.

Region	Baltic Region	Central Europe	Southern Europe
Initial investment, I, €/m2	1.1-1.3	1.1-1.3	1.1-1.3
Maintenance cost, M, €/m2 p.a.	0	0	0
Labour intensity	Low	Low	Low
Technical Lifetime, n, years	15	15	15
Energy savings, □E, kWh/m2 p.a.	4.3-5.3	4.3-5.3	4.3-5.3
Cost of Saved Energy, CSE ((I+n*M)/(n*□E)), €-cent/kWh	1.4-2.0	1.4-2.0	1.4-2.0

Application

Limitation of draw-off capacity can be applied to all types of buildings and all kinds of taps.

However, one should be aware, that taps where a certain amount of water is required, e.g. filling of buckets, will not benefit from reduction of maximum flow.

Implementation

Work on the domestic water installation should be carried out by qualified plumbers.

Supervision/Quality assurance

The domestic water installation should be pressure tested subsequent to alteration.

Maintenance

No additional maintenance will be required.

Side effects

By reducing the maximum capacity of hot water taps, the time to fill tubs and bowl will be increased.

UDW 2: Regulation of hot water temperature

Basic principle

By lowering the temperature of the domestic hot water supply energy losses from hot water tanks and pipes can be reduced. The lowest but still satisfactory supply temperature is depending on the actual conditions.

If no control exists for regulating the hot water temperature, a thermostatic valve can be fitted to obtain the lowest possible but satisfactory supply temperature to the hot water tank and/or hot water distribution system.

Investment and savings

Region	Baltic Region	Central Europe	Southern Europe
Initial investment, I, €/m2	0.9-1.1	0.9-1.1	0.9-1.1
Maintenance cost, M, €/m2 p.a.	0	0	0
Labour intensity	Low	Low	Low
Technical Lifetime, n, years	10	10	10
Energy savings, □E, kWh/m2 p.a.	1.4-1.8	1.3-1.6	0.9-1.1
Cost of Saved Energy, CSE ((I+n*M)/(n*□E)), €-cent/kWh	5.1-7.6	5.6-8.4	8.4-12.5

Application

Regulation of hot water temperature can be carried out in all type of buildings.

Implementation

If no regulation exists, a short interruption of heat supply will be necessary.

Supervision/Quality assurance

The pipe work should be pressure tested subsequent to the installation of new fittings.

Maintenance

The regulating valve should be inspected regularly for correct functionality.

Side effects

Reduction of hot water temperature can make doing the dishes more difficult. Tests have shown that hot water temperature of 50 °C is sufficient to rinse off grease from pans and dishes.

Growth of pathogenic bacteria within the domestic water installation can possibly increase. As bacteria such as Legionella can be fatal, it is important to eliminate this risk by periodically increase of the temperature to above 60 °C. It should be ensured, that the temperature increase is effective throughout the entire system.

UDW 3: Replacement of hot water tanks in DH systems

Basic principle

The efficiency of district heating systems depends to a large extent on the temperature difference between the supply and the return temperature. A large temperature difference will reduce the energy demand for circulation of water and a low return temperature will for some heat generators increase the thermal efficiency.

Older hot water tanks are typically not very good at transferring the heat to the domestic hot water and consequently the return water will have a high temperature. By replacing these tanks with new types with more efficient heat exchanger, the return temperature can be lowered to only 5 - 10 degrees above the inlet cold water temperature.

Unless the cost of district heating reflects the advantages of a low return temperature, the energy savings will not be directly transferred to the customer.

Investment and savings

Region	Baltic Region	Central Europe	Southern Europe
Initial investment, I, €/m2	0.7-0.9	0.7-0.9	0.7-0.9
Maintenance cost, M, €/m2 p.a.	0	0	0
Labour intensity	Low	Low	Low
Technical Lifetime, n, years	10	10	10
Energy savings, ΔE, kWh/m2 p.a.	1.4-1.8	1.3-1.6	0.9-1.1
Cost of Saved Energy, CSE ((I+n*M)/(n*ΔE)), €-cent/kWh	4.2-6.3	4.6-6.9	6.9-10.4

Application

The measure can be applied in all types of buildings with poor utilization of district heating for heating of domestic hot water.

Implementation

Unless there are more than one tank or there is sufficient space for installation the new tank next to the old one, it will be necessary to cut off hot water supply to the building during replacement of the tank.

Supervision/Quality assurance

The pipe work should be pressure tested subsequent to the installation of the new tank.

Maintenance

No additional maintenance will be required.

Side effects

There are no side effects.

Utility measures - water for domestic use

UDW 4: Heat recovery, preheating of domestic hot water

Basic principle

Energy can be recovered from various sources, depending on availability.

As described in UV 4, energy can be recovered from exhaust air by means of a heat pump. As the heat pump is able to transport heat from a lower to a higher temperature level, the energy from the exhaust air can be utilized to heat or preheat the domestic hot water if preheating the inlet air is not desirable.

Buildings with a cooling plant where the hot water consumption also is large, e.g. hotels, can profit from utilizing the heat from the condensers.

Investment and savings

Region	Baltic Region	Central Europe	Southern Europe
Initial investment, I, €/m2	3.2-3.9	3.2-3.9	-
Maintenance cost, M, €/m2 p.a.	0.3-0.4	0.3-0.4	-
Labour intensity	Medium	Medium	-
Technical Lifetime, n, years	10	10	-
Energy savings, □E, kWh/m2 p.a.	8.8-10.8	8.1-9.9	-
Cost of Saved Energy, CSE ((I+n*M)/(n*□E)), €-cent/kWh	3.3-4.9	3.6-5.3	-

Application

The measure is not relevant for Southern Europe. For the Baltic region and Central Europe preheating of domestic hot water by recovered heat can be applied in buildings with excess heat available, e.g. from exhaust air or cooling systems.

Implementation

It is recommended to employ a consultant to undertake a proper feasibility study.

Supervision/Quality assurance

The efficiency of the heat recovery can be measured subsequent to installation.

Maintenance

The measure will introduce additional installations and consequently additional maintenance. The annual maintenance costs are estimated to be 2-5 % of the initial investment.

Side effects

The installations may require additional utility space.

3.6 Utility measures - electrical

Electrical consumption for pumps, ventilation fans, cooling units and lighting of the interior accounts for a considerable part of the total energy consumption in most office buildings, schools, hotels etc. As the production of electricity usually is done at a far lower efficiency rate than heating, there is a large potential for saving primary energy by reducing the needs for electrical energy.

Utility measures - electrical

UE 1: Lighting - installation of presence detectors

Basic principle

Installation of presence detectors in buildings or parts of buildings which are not continuously occupied. The presence detectors switch off the light when there are no people in the concerned parts of the building.

Investment and savings

It is assumed that the building is in use 2,500 hours pr. year. Further, it is assumed that the concerned part of the building is occupied 45 % of the usage time. However, because of the time used to keep the light on during the presence of people in the corridor, the „OFF"-time is set to 50 %.

Region	Baltic	Central Europe	Southern Europe
Initial investment, I, €/m2	5	5	5
Maintenance cost, M, €/m2 p.a.	0.1	0.1	0.1
Labour intensity	Low	Low	Low
Technical Lifetime, n, years	15	15	15
Energy savings, □E, kWh/m2 p.a.	12	12	12
Cost of Saved Energy, CSE ((I+n*M)/(n*□E)), €-cent/kWh	3	3	3

Application

Office buildings, industry buildings, schools, common areas in apartment buildings (corridors, staircases etc.) which are not continuously occupied.

Implementation

The equipment can be immediately installed.

Supervision/Quality assurance

No special supervision or quality assurance is needed.

Subsequent minor adjustments may be necessary during the first six months.

Side effects

By reducing the use of the light the heat produced from the lights sources is also reduced. This implies an increased heat demand in the heating season, but also possibly a reduced cooling demand in the summertime. In order to control the heating supply most efficiently it is desirable to minimize the heat output from the lighting.

UE 2: Lighting - daylight control (on/off)

Basic principle

In rooms with sufficient daylight within the normal working hours the light may be switched off automatically. The savings vary a lot from room to room depending on location.

It should be emphasized that the daylight control does not have to be made in the entire building. One daylight sensor may control many rooms.

Investment and savings

It is here assumed that the daylight is sufficient in 15% of the time.

Region	Baltic	Central Europe	Southern Europe
Initial investment, I, €/m2	4	4	4
Maintenance cost, M, €/m2 p.a.	0.1	0.1	0.1
Labour intensity	Low	Low	Low
Technical Lifetime, n, years	20	20	20
Energy savings, ΔE, kWh/m2 p.a.	5	5	5
Cost of Saved Energy, CSE ((I+n*M)/(n*ΔE)), €-cent/kWh	6	6	6

Application

Office buildings, industry buildings, schools, common areas in apartment buildings (corridors, staircases etc.) with sufficient daylight.

Implementation

The equipment can be immediately installed.

Supervision/Quality assurance

No supervision or quality assurance is needed.

Maintenance

Subsequent minor adjustments may be necessary during the first six months.

Side effects

By reducing the use of the light the heat produced from the lights sources is also reduced. This implies an increased heat demand in the heating season, but also possibly a reduced cooling demand in the summertime. In order to control the heating supply most efficiently it is desirable to minimize the heat output from the lighting.

Utility measures - electrical

UE 3: Lighting - daylight control (continuous)

Basic principle

In rooms with daylight within the normal working hours the artificial light may be dimmed automatically. The savings vary a lot from room to room depending on location.

It should be emphasized that the daylight control does not have to be made in the entire room. One daylight sensor may control many rooms.

Fluorescent tubes with luminaires should be fitted with dimmable HF lamp ballasts in order to be able to dim the light.

Investment and savings

It is assumed that the daylight is sufficient in 15% of the time and can replace the artificial lighting partly in another 40% of the time. The energy savings are assumed to be totally 45%. The calculations are based on replacement of all luminaires with new luminaires with dimmable HF lamp ballasts.

Region	Baltic	Central Europe	Southern Europe
Initial investment, I, €/m2	17	17	17
Maintenance cost, M, €/m2 p.a.	0.5	0.5	0.5
Labour intensity	Medium	Medium	Medium
Technical Lifetime, n, years	15	15	15
Energy savings, □E, kWh/m2 p.a.	17	17	17
Cost of Saved Energy, CSE ((I+n*M)/(n*□E)), €-cent/kWh	10	10	10

Application

Office buildings, industry buildings, schools, common areas in apartment buildings (corridors, staircases etc.) etc. with daylight.

Implementation

The equipment can be immediately installed.

Supervision/Quality assurance

No supervision or quality assurance is needed.

Maintenance

Subsequent minor adjustments may be necessary during the first six months.

Side effects

By reducing the use of the light the heat produced from the lights sources is also reduced. This implies an increased heat demand in the heating season, but also possibly a reduced cooling demand in the summertime. In order to control the heating supply most efficiently it is desirable to minimize the heat output from the lighting.

UE 4: Energy saving lamps

Basic principle

Replacement of incandescent lamps with energy saving lamps is a very simple measure; however the energy saving potential is significant. It should be noted that energy saving lamps not always are suitable. For some purposes incandescent lamps are preferable. It is suggested to test if energy saving lamps are suitable for a certain purpose by replacing just one lamp as a test and then replace the rest of the lamps if the lighting from the energy saving lamp is satisfactory.

In general energy saving lamps use less than 20 % of the electricity of incandescent lamps i.e. a 60 W incandescent lamp can be replaced by a 11 W energy saving lamp.

Investment and savings

The calculations are based on replacement of one single incandescent lamp of 60W with one 11W energy saving lamp and a usage time of 2,500 hours pr. year.

Region	Baltic	Central Europe	Southern Europe
Initial investment, I, €/lamp	4	4	4
Maintenance cost, M, €/lamp p.a.	0	0	0
Labour intensity	Low	Low	Low
Technical Lifetime, n, years	4	4	4
Energy savings, ΔE, kWh/lamp p.a.	120	120	120
Cost of Saved Energy, CSE ((I+n*M)/(n*ΔE)), €-cent/kWh	1	1	1

Application

Office buildings, industry buildings, schools, hotels, dwellings etc. It shall be noted that fluorescent tubes in general is the most efficient form of lighting for larger rooms. It is therefore not recommended to replace fluorescent tubes with energy saving lamps. This will also require replacement of mountings and fixtures which most likely not will be economically feasible.

Implementation

The equipment can be immediately installed.

Supervision/Quality assurance

No supervision or quality assurance is needed.

Maintenance

No additional maintenance is needed. As the lifetime of energy saving lamps are far longer (5 to 10 times) than for incandescent lamps, the frequency of replacing lamps will be reduced significantly.

Side effects

By reducing the use of the energy for lighting the heat produced from the lights sources is also reduced. This implies an increased heat demand in the heating season, but also possibly a reduced cooling demand in the summertime. In order to control the heating supply most efficiently it is desirable to minimize the heat output from the lighting.

Utility measures - electrical

UE 5: New light fixtures

Basic principle

Within the last 25 years there has been a comprehensive development in efficiency for both luminaires and lamps.

By changing old luminaires to new energy-efficient ones it is possible to save up to 50% energy.

Some luminaires do not utilise the light very efficient as they absorb a lot of the light or reflect it into unintended areas.

Luminaires, which have a more efficient design, reflect a far larger fraction of the light onto the areas, where the light is intended.

Investment and savings

The calculations are based on savings of 40 % of 25 W/m2.

Region	Baltic Region	Central Europe	Southern Europe
Initial investment, I, €/m2	25	25	25
Maintenance cost, M, €/m2 p.a.	0	0	0
Labour intensity	Medium	Medium	Medium
Technical Lifetime, n, years	10	10	10
Energy savings, □E, kWh/m2 p.a.	15-20	15-20	10-18
Cost of Saved Energy, CSE ((I+n*M)/(n*□E)), €-cent/kWh	14-18	14-18	15-28

Application

Can be applied to all types of buildings.

Implementation

Changing of luminaires may cause some disturbance to the occupants. However, as the installation time is limited, it is possible to carry out the work during normal operating hours.

Supervision/Quality assurance

The level of lighting can be measured subsequent to installation.

Maintenance

No additional maintenance is required.

Side effects

The reduced energy consumption will result in fewer periods with high temperatures in the summertime and a little higher need for heating in the wintertime.

Utility measures - electrical

UE 6: Replacement of circulation pumps

Basic principle

Within the last 10 - 15 years there has been a comprehensive development in efficiency for pumps.

By replacement of older pumps, the energy savings are achieved partly due to reduced pump work as a result of intelligent control and partly due to an increased efficiency of the pump.

Investment and savings

The values in the table are based on replacement of the old circulation pumps (>8 years) to new efficient low energy pumps.

Region	Baltic Region	Central Europe	Southern Europe
Initial investment, I, €/m2	1.3-1.6	1.3-1.6	1.3-1.6
Maintenance cost, M, €/m2 p.a.	0	0	0
Labour intensity	Low	Low	Low
Technical Lifetime, n, years	10	10	10
Energy savings, ΔE, kWh/m2 p.a.	2.3-2.9	2.1-2.6	1.4-1.7
Cost of Saved Energy, CSE ((I+n*M)/(n*ΔE)), €-cent/kWh	4.7-7.0	5.2-7.7	7.7-11.5

Application

The measures can be applied for all buildings where water is used as heat conducting fluid.

Implementation

The pump replacement can be carried out without longer interruptions in the operation of the heating system.

Supervision/Quality assurance

A pressure test should be performed when the pump has been replaced.

Maintenance

The improvement does not result in any additional maintenance.

Side effects

A modern intelligent pump is able to reduce the head when valves in the system reduce the flow. If there have been noise problems due to high pump head and large flow these will be reduced.

UE 7: Replacement of ventilation fans / air handling units

Basic principle

Within the last 10 - 15 years there has been a comprehensive development in efficiency for ventilation fans.

Energy is saved due to increased efficiency of fans and motors and a reduction of the pressure losses within the ventilation unit itself. Intelligent control of motor speed makes belt driven fans obsolete.

Investment and savings

The values in the table are based on replacement of the ventilation unit for an office building. The building comprises 2,500 m2 of floorage and the height of the rooms is 2.8 m. For the calculations a constant air change of 0.5 h-1 and a pressure difference of 1 kPa in the ventilation ducts are assumed.

Region	Baltic Region	Central Europe	Southern Europe
Initial investment, I, €/m2	1-1.2	1-1.2	1-1.2
Maintenance cost, M, €/m2 p.a.	0	0	0
Labour intensity	Medium	Medium	Medium
Technical Lifetime, n, years	10	10	10
Energy savings, ΔE, kWh/m2 p.a.	1.1-1.4	1.1-1.4	1.1-1.4
Cost of Saved Energy, CSE ((I+n*M)/(n*ΔE)), €-cent/kWh	7.0-10.4	7.0-10.4	7.0-10.4

Application

The improvement can be applied to all buildings with an existing mechanical ventilation system.

Implementation

The replacement of the ventilation unit can be carried out without longer interruptions of the ventilation system.

Supervision/Quality assurance

The performance can be checked on the spot.

Maintenance

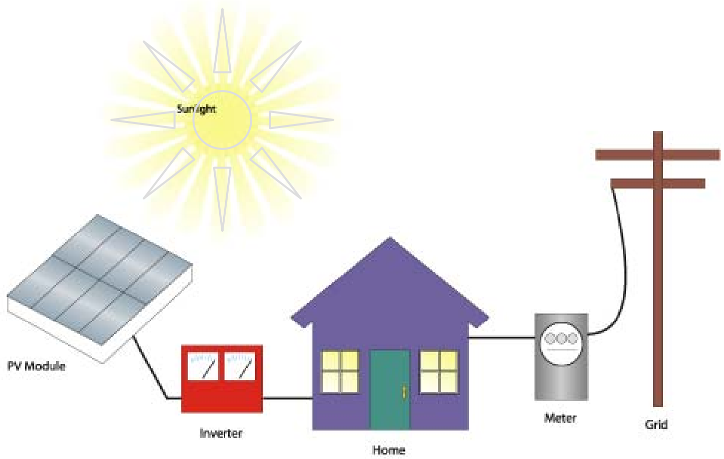
If the existing fans are belt driven, periodically inspection and replacement of belts will be avoided.

Side effects

Replacement of fans and air handling units can result in reduced noise and better overall performance.

UE 8: Solar PV-systems

Basic principle



A photo voltaic solar system (PV-system) converts the sunrays into electricity. Solar PV system may either be connected to the electricity grid or run in stand-alone mode with batteries as energy storage. When connected to the electricity grid the surplus electricity is usually sold to the electricity company at a fixed prize, which is subject to national subsidy schemes.

Installation of a solar PV system does not result in energy savings, but leads to reduction of emission of pollutants and CO_2 by replacing conventional energy sources for electricity production such as coal.

Investment and savings

The results below are based on installation of a 50 kW ground mounted Solar System, which is connected to the electricity grid. It provides distributed energy and excludes any back up power. Further, it is assumed that the building comprises 50 dwellings with an area of 50 m2 each. Thus the total floorage is 2,500 m2.

Region	Baltic Region	Central Europe	Southern Europe
Initial investment, I, €/m2	78-95	78-95	78-95
Maintenance cost, M, €/m2 p.a.	0.5	0.5	0.5
Labour intensity	Medium	Medium	Medium
Technical Lifetime, n, years	20	20	20
Energy savings, □E, kWh/m2 p.a.	10-12	15-19	20-25
Cost of Saved Energy, CSE ((I+n*M)/(n*□E)), €-cent/kWh	35-51	23-34	18-26

Application

Solar PV system are best suited for buildings in regions with large amount of solar radiation and with:

Limited shadows from surrounding buildings and/or trees.
Sufficient and usable roof area.
Other planned renovations of e.g. the roof. This implies lower establishment cost and easier integration with the building construction. This also applies for new buildings.

Solar PV systems are not suited for buildings with:

Inexpensive energy back up (e.g. production enterprises)

Implementation

As the technique is still rather expensive, it is most feasible if the solar panels can substitute other building materials such as roof or façade cladding.

Supervision/Quality assurance

The complexity of solar PV systems calls for quality assurance performed by a certified electrician.

Maintenance

To maintain the efficiency of the panels, a certain amount of cleaning must be foreseen, especially in polluted areas.

Side effects

Solar PV-systems will affect the architecture of the building. If this is a focus point, care should be taken to integrate the panels in an appropriate manor.

A PV-system will add to the image of the owner as thinking of sustainability.

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