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Efficient Heat Insulation in Building Modernization

Reduction of Cost and CO_2 Emission
by Efficient Manufacturing of Heat Insulation
in Building Modernization

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Summary

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1. Target

It was the aim of this investigation to find and describe methods for efficient manufacturing high quality heat insulation in existing buildings. In particular such methods had to be examined with regard to adaption to existing buildings, that are already applied in new buildings. Cost reduction and rationalization mean to achieve maximum effect - in this case high quality heat insulation - by minimum effort.

2. Investigation

2.1 Measures of manufacturing and organization

In new buildings heat insulation is carried out in the course of other construction work. Appropriate prefabrication of building elements, efficient organization of the construction site and appropriate course of work are obvious rules. In contrast the application of heat insulation in building modernization is subject to quite different conditions.

Manufacturing measures follow the rules of new building construction though to different extent, depending on the special conditions of the project. Important measures for efficient manufacturing are, among others:

- prefabrication and preparation of building elements,
- application of erection aids and devices,
- efficient transportation and avoidance of intermediate storage.

Organizational measures have a special potential for improving the efficiency of heat insulation work. The most important decisions are made in the early planning stages. As in new buildings, heat insulation measures have to be considered in the first steps of planning, if rational execution is to be achieved.

But also in later steps of planning, contracting, preparation of execution, logistics and site organization rationalization effects can be achieved. As in new building cost efficiency of decisions decreases with the progress of execution, but even in the heat insulation works themselves rationalization effects of 15 % and above are mentioned by contractors due to better organization and logistics.

2.2 Building elements with improved heat insulation

For **exterior walls** the most important measures of improving heat insulation are

- **integrated heat insulation systems**, available on the market in a great variety of designs and scales of costs,
- heat insulation behind **ventilated curtain walls,** being physically simple, suitable for prefabrication but less economical,
- **inside insulation** as a more traditional means, allowing to maintain the appearance of the building, but needing special care in execution.

The replacement of **windows** in building modernization causes most energetic effect with the least expence. This is generally valid, even if there ist a large range of costs, depending on quality standard and installation conditions. Modern windows are products of high quality, efficient manufacturing, installation on site can be improved by prepared or prefabricated connecting devices. Improvement of existing windows is of little practical importance.

With respect to heat insulation different types of **roofs** have been investigated:

- **pitched roofs not used as living space** - heat insulation on the uppermost floor is easy to improve, even by self-help,
- **pitched roofs with living space**, which are very frequent - traditional methods for improvement of heat insulation are common, unless a complete renovation of the roof is necessary,
- **flat roofs** - a good technical state assumed additional layers of appropriate heat insulation materials can be added almost without changing the existing insulation,
- **heightening by an additional attic storey** - here the application of light weight constructions with large prefabricated compound units is possible in a very efficient way.

2.3 Rationalization Potentials

For thermal improvement of **single compound units** potentials of rationalization have been determined in examples and related to wage costs. They are between 3 % with a simple integrated heat insulation system and 8 % with inside insulation. The reason for this comparatively low potential is, that the example and the applied technologies leave only little room for the application of more efficient manufacturing methods.

Concerning **integrated measures,** different combinations of thermal improvement of single compound units have been compared. The examples have been chosen to compare the same improvement of heat insulation by different means and in different quality standards. In consequence different basic costs are the starting point. The selection of these means is the task of the design phase. Due to methodical reasons, no calculable effect of rationalization was assumed, even though in reality there is a very high potential.

The effect of rationalization on total costs - wage costs and costs of materials - is shown in table 1. It contains basic costs with their shares of wage and material costs, as well as the factors of rationalization achievable in four steps from planning to erection.

Heightening by an additional attic storey is not included, because it is more similar to new construction. The assumed costs are orientation data, based on information collected from contractors for the year 1999. Costs of the most simple („min.“) and the best („max.“) alternative differ by the factor 1.5 to 2.0, in some cases the difference may be even higher.

Tab. 1 Assumed basic costs and rationalization factors for the example calculations (1,- DM = 0,51 Euro)

		basic costs			rationalization factors				
		costs [DM/m²]	share of wages	share of materials	design and contracting	prep. of execution	prefabri-cation	erection, mechan.	total
integrated heat insulation syst.	min. max	100,- 150,-	0,50 0,65	0,50 0,35	1,00 1,00	1,00 1,00	0,98 0,97	0,97 0,96	0,95 0,93
ventilated curtain walls	min. max	200,- 400,-	0,40 0,60	0,60 0,40	1,00 1,00	1,00 1,00	0,95 0,90	0,95 0,90	0,90 0,81
inside insulation	min. max	80,- 130,-	0,50 0,65	0,50 0,35	1,00 1,00	1,00 1,00	0,97 0,95	0,97 0,95	0,94 0,90
impr. of existing windows	min. max	50,- 250,-	0,60 0,90	0,40 0,10	1,00 1,00	1,00 1,00	1,00 1,00	1,00 1,00	1,00 1,00
new windows	min. max	350,- 700,-	0,20 0,50	0,80 0,50	1,00 1,00	1,00 1,00	0,95 0,90	0,98 0,95	0,93 0,86
pitched roof not used as liv. sp.	min. max	25,- 50,-	0,50 0,70	0,50 0,30	1,00 1,00	1,00 1,00	0,95 0,95	0,95 0,95	0,90 0,90
pitched roof with living sp..	min. max.	100,- 150,-	0,60 0,70	0,40 0,30	1,00 1,00	1,00 1,00	0,95 0,90	0,95 0,90	0,90 0,81
flat roof	min. max.	80,- 150,-	0,50 0,70	0,50 0,30	1,00 1,00	1,00 1,00	0,95 0,95	1,00 1,00	0,95 0,95

Figures 1 to 5 show the rationalization potential in relation to different quality standards of a complete modernization of exterior walls, windows and roofs. The assumed conditions are

1. **minimal basic costs**, integrated heat insulation system, improvement of existing windows (fig. 1),
2. **high quality standard** for exterior walls, windows, and roof with living space (fig. 2),
3. **low total costs** with inside insulation and new windows (fig. 3),
4. **outer appearance worthy of preservation,** and roof with living space on high quality standard (fig. 4),
5. **integrated heat insulation system on high quality standard**, new windows, and renovation of flat roof (fig. 5).

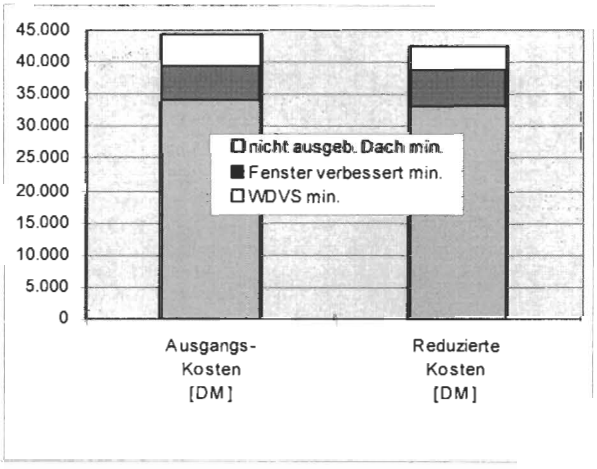

fig. 1

rationalization potential of a simple modernization
- integrated heat insulation system with minimal basic costs
- improvement of existing windows, minimal basic costs,
- heat insulation of the uppermost floor, minimal basic costs
rationalization potential about 4 %

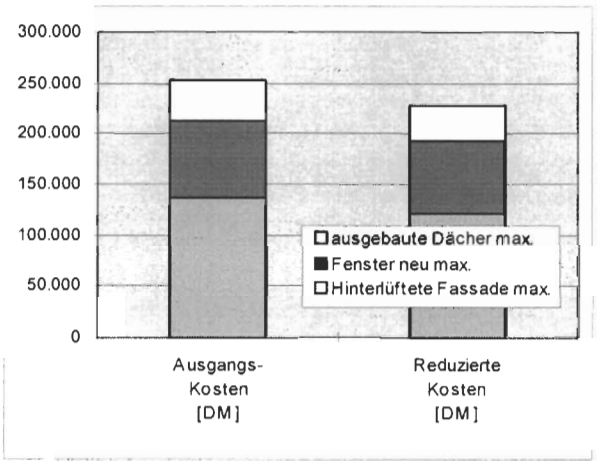

fig. 2

rationalization potential of a modernization on a high quality standard
- ventilated curtain wall on a high quality standard
- new windows with a high quality standard
- heat insulation of a pitched roof with living space

rationalization potential about 10 %

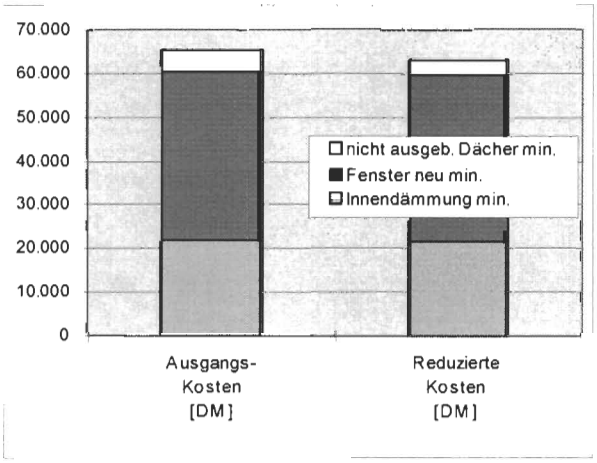

fig. 3

rationalization potential of a simple modernization
- inside insulation on a low quality standard
- new windows on a low quality standard
- heat insulation of a pitched roof without living space (uppermost floor) at minimal basic costs

rationalization potential about 2 %

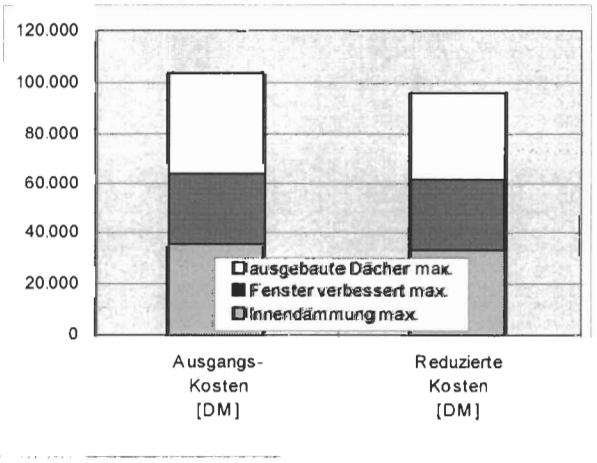

fig. 4

rationalization potential of a modernization with appearance worthy of preservation
- inside insulation with high quality standard
- improvement of existing windows
- heat insulation of pitched roof with living space on a high quality standard
rationalization potential about 7 %

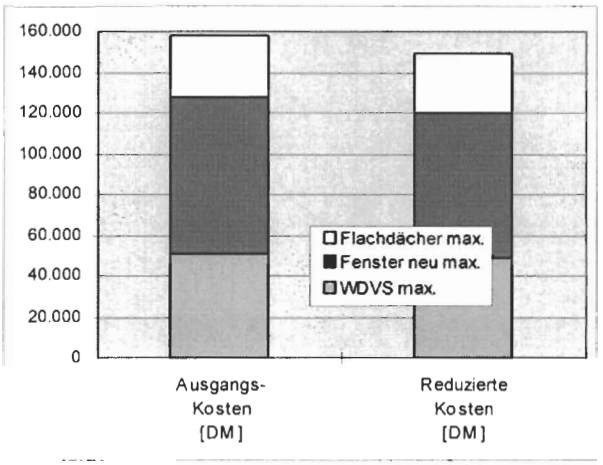

fig. 5

rationalization potential of a modernization with high quality standard and renovation of the flat roof
- integrated heat insulation system on a high quality standard
- new windows on a high quality standard
- additional heat insulation on flat roof with new proof parapet
rationalization potential about 6 %

3. Summary and Results

The cost differences show the potential scale of of savings, based on rationalization measures for different quality standards.

- The **highest potential** - about 10 % of the basic costs - is that of alternative 2. This alternative has a high quality standard and high basic costs for exterior walls, windows and roof. It allows a high degree of prefabrication and the use of machines for roof insulation. The amount of money saved by rationalization is the highest as well.
- The **lowest potential** - about 2 % of the basic costs - is that of alternative 3, even with the assumption of self-aid. It contains inside insulation, new windows on low quality standard and a simple heat insulation on the uppermost floor under a pitched roof.
- In principle **high potentials** are found in those examples, that have comparatively costly constructions. These are for example the ventilated curtain wall, new windows and the insulation of roofs combined with creation of living space.

Rationalization potential of the steps „design and contracting“ as well as „preparation of execution“ is found in decisions for methods, that often cannot be compared with regard to their quality standards. Possible influences on rationalization potentials are clearly higher than in the following steps when taken decisions "only" have to be realized.

The measures for efficient manufacturing of high quality heat insulation in existing buildings are summarized in a check list in the detailed report. This list points in practice to possible measures of rationalization, corresponding to the steps of planning. The application of those measures in all stages will result in additional synergy effects.