WP 4 Energy

# Analyses of EE in typical buildings and of the state of the energy supply infrastructure

## Analysis of EE in three typical buildings and suggested EER measures in Grodno target area

April 2010

GRODNO OBLAST
EXECUTIVE COMMITTEE

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# Introduction of WP 4

With Work Package 3 (Urban Development) and Work Package 5 (Financial Instruments) the Work Package 4 (Energy) forms a strongly interrelated union of prospects to the new EU member states.

The project partners of Work Package 4 (WP 4) will work on the following subjects:

- Analyses of the energy supply systems and the status of the building stock regarding energy efficiency (EE) in the selected target areas
- Elaboration and partly implementation of concepts concerning energy efficient refurbishment (EER) measures and modernisation of the energy supply systems
- Exchange of know-how and experiences during workshops and seminars

Concerned stakeholders (energy providers, municipality, owners and residents) are intended to be involved to guarantee a long-lasting effect.

## Energy Efficient Refurbishment of Buildings

The project partners jointly generate and analyse conceptions concerning EER measures of buildings in the target areas. The aim is the realization of an optimized and complex package of measures elaborated which leads to an improvement of the EE in the building stock.

## Energy Supply Infrastructure

Besides EER measures a closer look at the renewal of the energy supply infrastructure is taken. New concepts should deal with different forms of district heating, combined heat and power systems and renewal energy.

## Exchange of know-how and experiences

The transfer of knowledge should lead in practice guidelines and recommendations for EER approaches and heat supply.

# Project Partners

The Grodno Oblast Executive Committee developed with the support of the Energy Agency of the Investitionsbank Schleswig-Holstein an optimized complex package of EER measures and changes in the energy supply infrastructure for three buildings in Lida/Belarus.

The Energy Agency of the Investitionsbank Schleswig-Holstein collected data of the three buildings and generated a model of each object. Based on these models three different options were elaborated for each building.

As frame of reference the German Energy Saving Ordinance (EnEV) in its latest edition 2009 was set.

# Attachments

## 1. Sovetskaya 43

**Investitionsbank** Schleswig-Holstein

**IB.ImmobilienCheck**

**Energetic and economic examination**
Selected energy-saving options
and basis of calculation

Construction project:

**Multi-family House - Energy-saving measures**
Sovetskaya 43
231300 Lida
Belarus

Investor:

Grodno Oblast Executive Committee
Housing Department
230023 Grodno
Belarus


Investitionsbank Schleswig-Holstein

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## Please note

This document is based on the IB.ImmobilienCheck by the Investitionsbank Schleswig-Holstein. For this project it is extended by information on German framework and energy-saving measures. The first part deals with German framework and terms of energy-saving in general. The second part displays the actual building.

# Part 1 – Information on energy-saving in Germany

## German Energy Saving Ordinance (EnEV)

In Germany the refurbishment of buildings is subject to the German Energy Saving Ordinance.
(German: Energieeinsparverordnung - short: EnEV) The latest version was published in 2009.

**What does the German Energy Saving Ordinance (EnEV) stipulate?**

- Energy performance certificates for buildings.
- Minimum energy requirements for new buildings.
- Minimum energy requirements for modernisation, reconstructions and extensions of existing buildings.
- Minimum requirements for heating, cooling and air-conditioning systems as well as hot-water systems.
- Energy inspection of air-conditioning systems.

**For which buildings does the German Energy Saving Ordinance (EnEV) apply?**

- For all heated and cooled buildings and/or parts of buildings.
- Special stipulations apply for buildings which are not heated, cooled or used regularly (such as holiday homes), which are erected only for a short period of time (such as tents, air halls) or which are used for special purposes, such as stables and greenhouses.
- Small buildings with a floor space of less than 50 m² and historic monuments protected by German land law are not obliged to produce energy performance certificates.

**Requirements for commercial buildings**

Like residential buildings, the requirements for new commercial buildings are defined by the annual primary energy demand. However, in addition to the energy demands for heating, hot water and air conditioning, the balance sheet also includes the proportion of energy for cooling and lighting installations. The new comprehensive calculation method is defined in the new German standard DIN V 18599. The requirements are defined by means of a reference building which corresponds to the real building in terms of geometry, net floor area, orientation and utilisation, but whose technical structure is defined according to Enclosure (2) of the German Energy Saving Ordinance (EnEV). The energy quality of the building cladding and the limitation of the insulation parameter are prescribed as ancillary requirements.

## KfW Banking Group - Financial support program

The KfW Banking Group is a German government-owned development bank. It was formed in 1948 as part of the Marshall Plan. The KfW finances private residential property and environment-friendly measures.

In particular the KfW rewards the efforts of energy-saving in Germany with the "Efficiency House"-program. It supports homeowners in refurbishing their homes concerning energy-saving measures. The program offers low interest financing including subsidy. The subsidy depends on the amount of energy-saving measures and their effects. There are different categories in the "Efficiency House"-program. They are called **KfW 115**, **KfW 100** and **KfW 85**. The names refer to the reference building of the EnEV. The reference building fits the requirements of the EnEV for a new building.

The buildings are classified by two specific values:

- **annual demand for primary energy**
  This value $\mathbf{Q_p}$ shows the demand for primary energy of the building compared to the demand of the EnEV reference building in percent.
- **transmission heat loss**
  This value **H'T** shows the heat loss through the building envelope compared to the heat loss of the EnEV reference building.

For example: A building still fits the requirements of the KfW 115 category if it has up to 15 % more demand for primary energy than the reference building.

## Energy-saving measures in Lida

We evaluated the volume and the floor size and generated models of the buildings in Lida. The rating of these models bases on German standards for refurbishing houses. The different options calculated fit the requirements of the German support program by the KfW Banking Group.

The generated model of the current building forms the basis of our calculation. To reach the different target values of the KfW program we developed different options concerning energy-saving measures. In these options we took care of the construction components at first. With replacements and insulation we reduced the transmission heat loss and the demand for primary energy. Second we replaced the heat generation which reduced the demand for primary energy of the options.

To reach the German standards there have to be made substantial changes in the heat generation of the buildings. District heating and wood pellets may not be available on site. For this it is advised to accomplish the non-installation engineering measures first. The technical installations (such as district heating and wood pellets) should be done after.

## Specific information on building - Sovetskaya 43

For the calculations a 6th floor was added to the current building in Sovetskaya 43. The new floor fits the 2nd to the 5th floor in height, number of windows but not in its construction. For the 6th floor we had a wooden construction in mind. Due to the shortage of time and the aim of reduced costs in general we chose this type. The recommended construction is attached (Appendix 1).

The construction costs of the new floor are not included in the cost calculation of this building. They are attached (Appendix 2).

To fit the German standards we needed to replace the heat generator. In Option 1 and 2 we changed the supply of the district heating system from heating only to cogeneration of heat and power. This is beyond the energy efficient measures so we did not consider the costs for this change in our calculations.

## Agenda - What to do

The following list of priority shows what is to be done in which order. Between the first and the second phase should be enough time to measure the new demand for heat energy.

To ensure the quality of the energy-saving measures please mind the information given in the third chapter of the attached dena "Handbook for energy refurbishment of residential buildings in the Russian federation" in Russian language.

### First phase

1. Commencement of work at building site
2. Construction of the new floor
   a. Demolition of the old roof
   b. Constructing the exterior walls and the new roof
   c. Additional construction concerning the new floor
3. Energy-saving measures of the building envelope (No measures are needed for the new floor)
   a. Replacement of the entrance doors and the windows
   b. Insulation of the exterior walls

### Second Phase

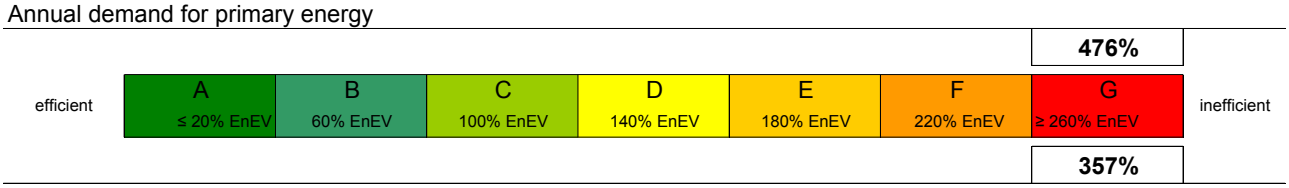
4. Measuring the new demand for heat energy on basis of the new requirement
5. Sizing and choosing the new heat generator
6. Installation of the new heat generator and additional technical components (heating, domestic hot water, ventilation)

# Part 2 – Energetic Examination

## Benchmark of current building with the extension of the new floor

Examination of the current building compared to the target value of EnEV 2009

Annual demand for primary energy

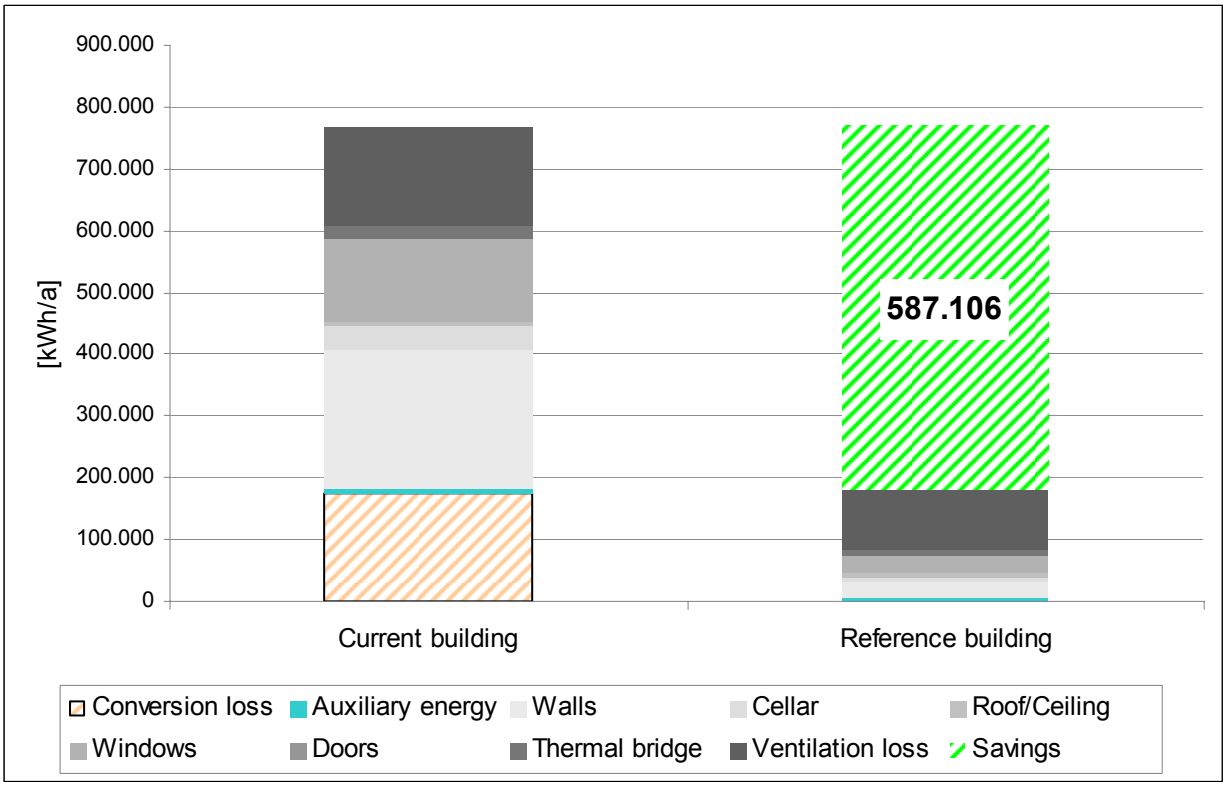



Transmission heat loss

## Rating of present heat loss

Overview of heat loss of the current building divided into construction components and technical installations.

For the purpose of comparison a reference building is shown. It matches the current building in form and cubature and fits the target values of EnEV 2009.




*Conclusion:*

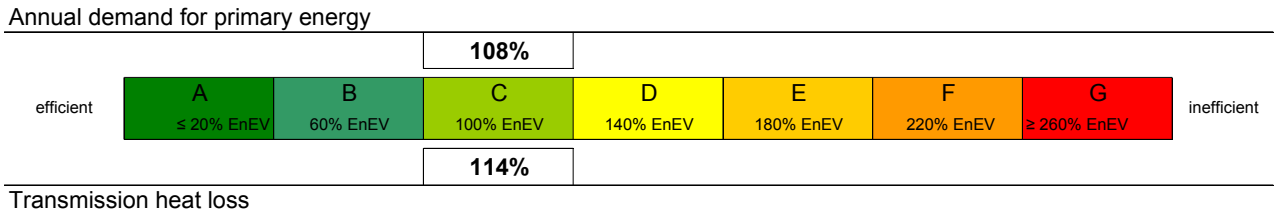
The building offers for all construction components the potential for energy-saving measures. Implementing these measures is going to lead to a reduction of transmission heat loss. As a result the heat generator will be oversized. This means a needless increase in stand-by losses. It is advisable the install a new heat generator fitting the new demand of heating energy.

## Selected energy-saving options

In Germany the KfW Banking Group rewards energy-saving measures.
The following options include the financial support of the KfW.

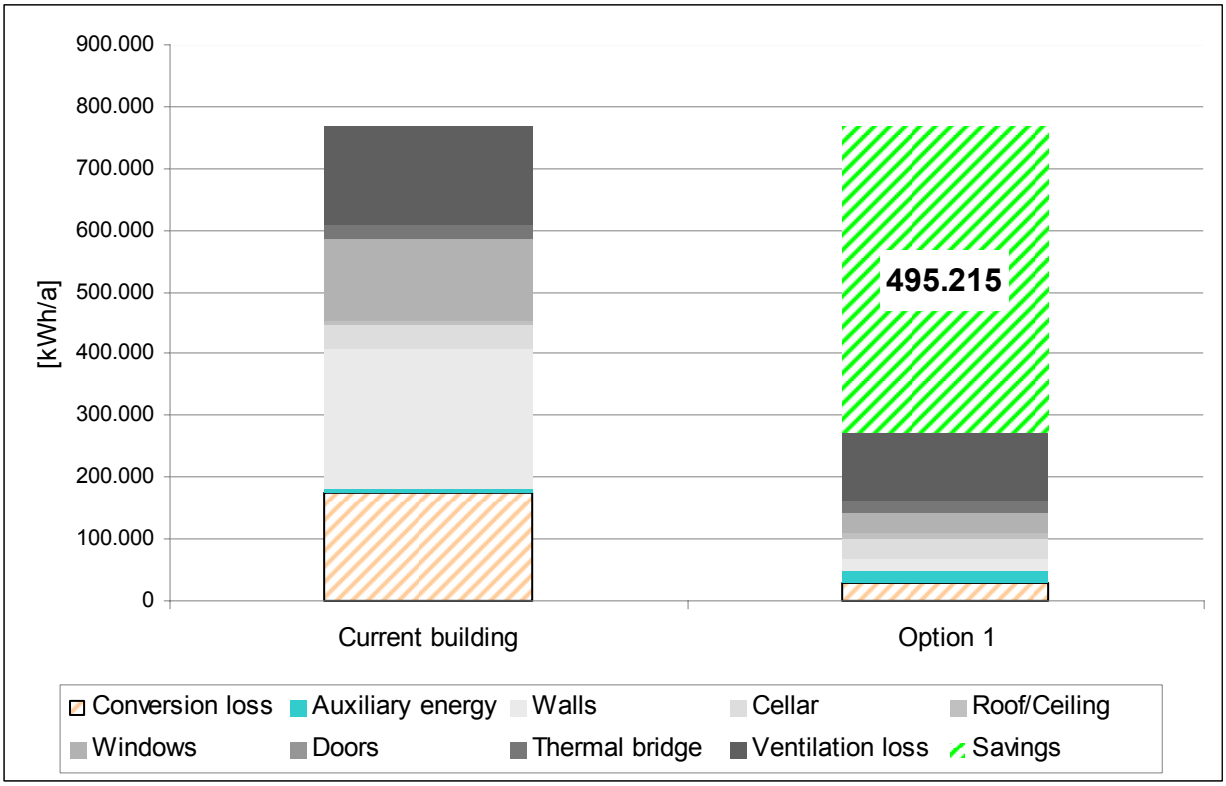
### Option 1: KfW 115

Classification of the energetic quality is based on the target values of EnEV 2009.




*Measures:*

- Insulation exterior wall (14 cm, thermal insulation composite system 035)
- Replacement Windows (Thermal transmission coefficient = 1,3 [W/(m²K)] )
- Replacement entrance doors (Thermal transmission coefficient = 2,0 [W/(m²K)] )
- Replacement heat generator (district heating, combined heat and power, fossil fuel)
- Installation solar domestic hot water with a bivalent cistern
- Installation decentralized exhaust-air plant with heat recovery and air density validation
- Replacement thermostatic valve (design range 1 kelvin)

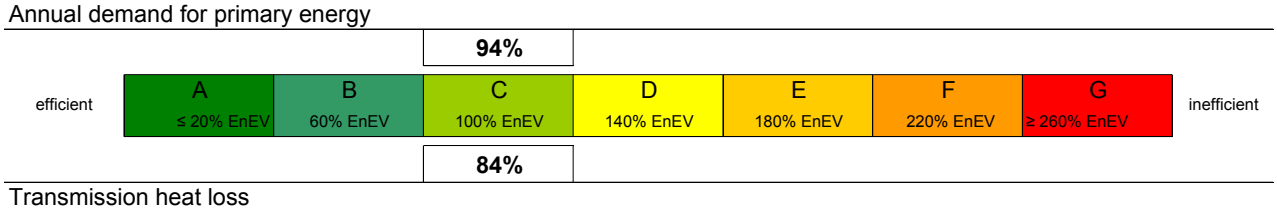



*Financing:*

- Support program: KfW - Energy-Efficient Rehabilitation, *Efficiency House 115*
- Conditions: low interest financing incl. subsidy in the amount of 7,5%

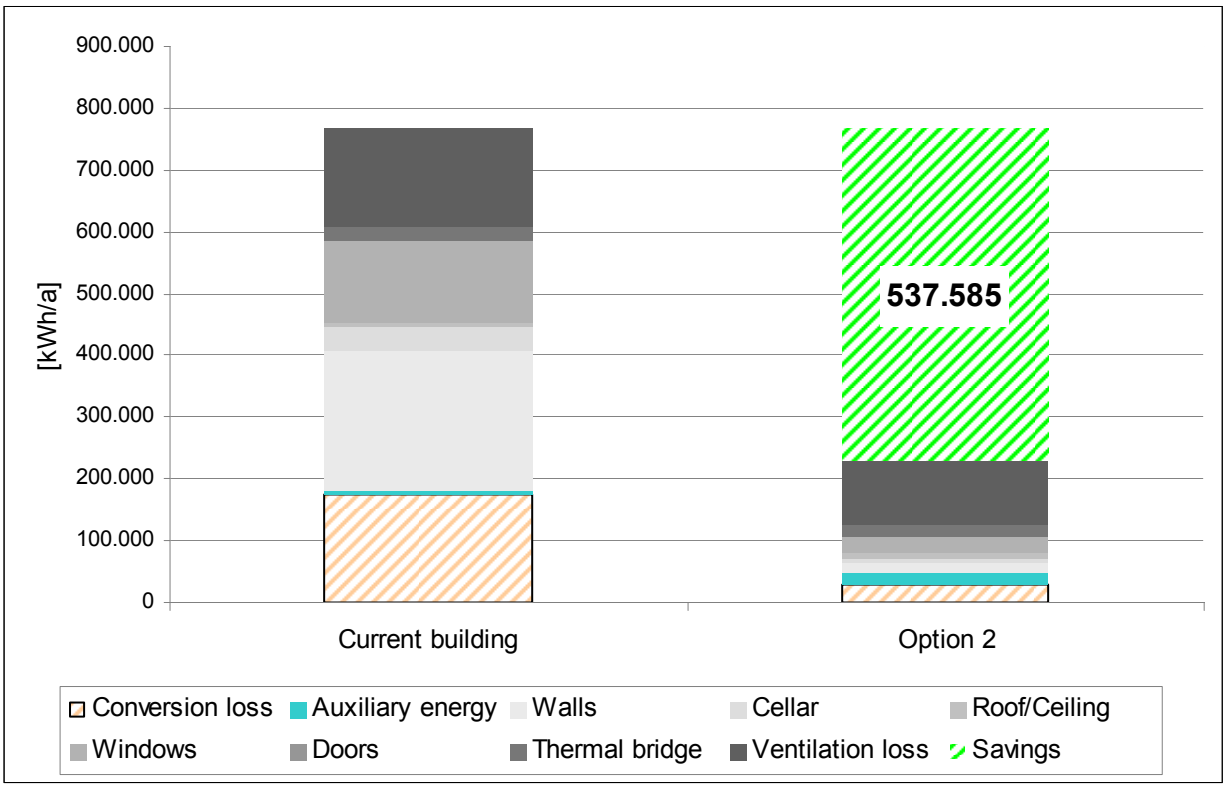
## Option 2: KfW 100

Classification of the energetic quality is based on the target values of EnEV 2009.




### *Measures:*

- Insulation exterior wall (18 cm, thermal insulation composite system 035)
- Replacement Windows (Thermal transmission coefficient = 1,1 [W/(m²K)] )
- Replacement entrance doors (Thermal transmission coefficient = 1,8 [W/(m²K)] )
- Replacement heat generator (district heating, combined heat and power, fossil fuel)
- Installation solar domestic hot water with a bivalent cistern
- Installation decentralized exhaust-air plant with heat recovery and air density validation
- Replacement thermostatic valve (design range 1 kelvin)
- Insulation basement (4 cm, thermal insulation composite system 035)

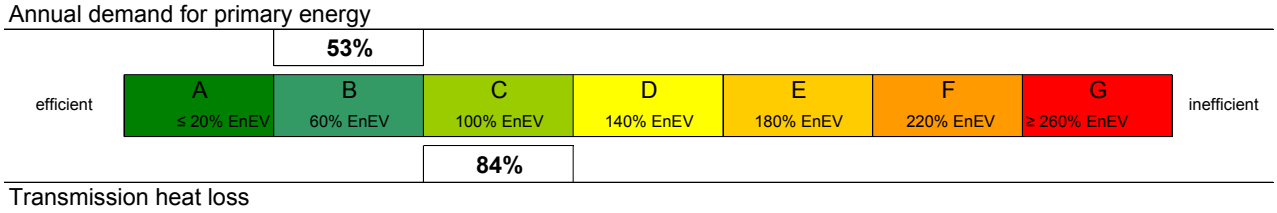



### *Financing:*

- Support program: KfW - Energy-Efficient Rehabilitation, *Efficiency House 100*
- Conditions: low interest financing incl. subsidy in the amount of 12,5%

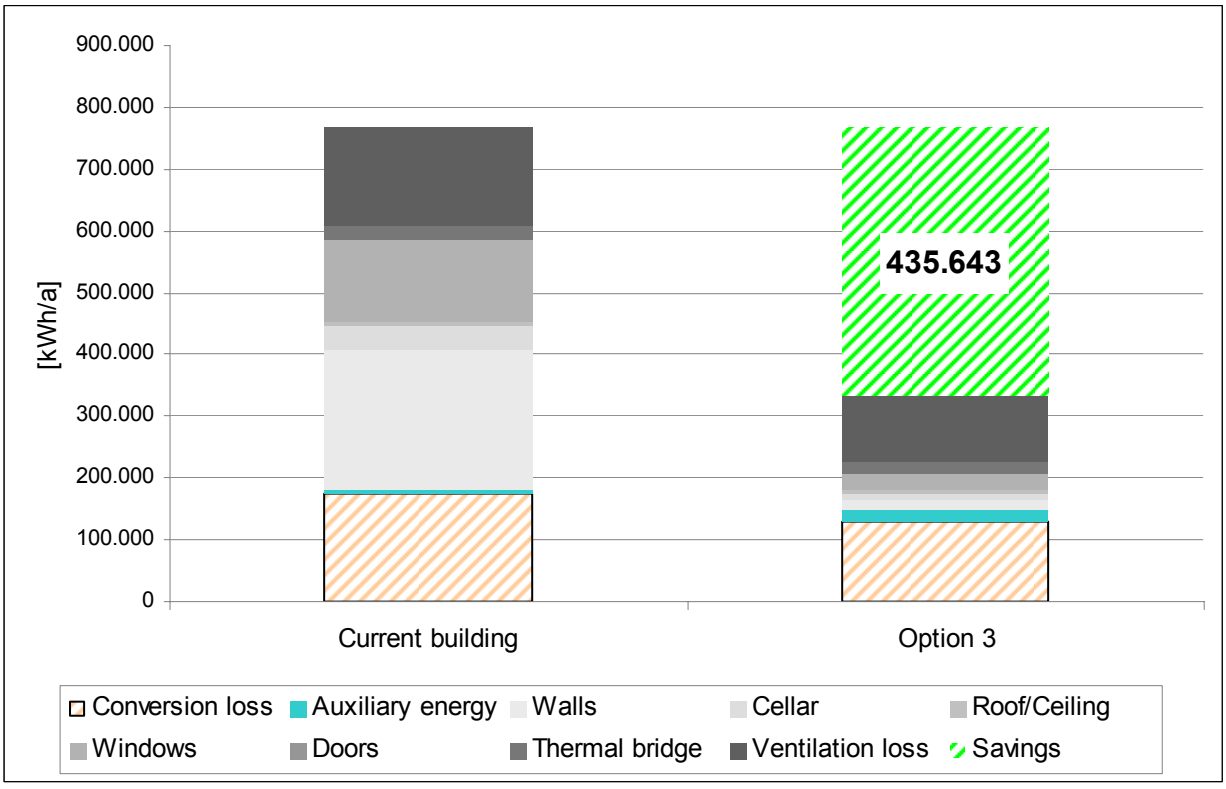
## Option 3: KfW 85

Classification of the energetic quality is based on the target values of EnEV 2009.




### *Measures:*

- Insulation exterior wall (18 cm, thermal insulation composite system 035)
- Replacement Windows (Thermal transmission coefficient = 1,1 [W/(m²K)] )
- Replacement entrance doors (Thermal transmission coefficient = 1,8 [W/(m²K)] )
- New heat generator (wood pellets)
- Installation solar domestic hot water with a bivalent cistern
- Installation decentralized exhaust-air plant with heat recovery and air density validation
- Replacement thermostatic valve (design range 1 kelvin)
- Insulation basement (4 cm, thermal insulation composite system 035)




### *Financing:*

- Support program: KfW - Energy-Efficient Rehabilitation, *Efficiency House 85*
- Conditions: low interest financing incl. subsidy in the amount of 15%

# Overview options

## Energy-saving measures

| Construction component | Option 1 | Option 2 | Option 3 |
|---|---|---|---|
| *KfW program*<br>*Subsidy* | Efficiency House 115<br>7,5% | Efficiency House 100<br>12,5% | Efficiency House 85<br>15% |
| | | | |
| Exterior wall | 14 cm (035) | 18 cm (035) | Same as Option 2 |
| Entrance doors | 2,0 [W/(m²K)] | 1,8 [W/(m²K)] | Same as Option 2 |
| Windows | 1,3 [W/(m²K)] | 1,1 [W/(m²K)] | Same as Option 2 |
| Basement | - | 4 cm (035) | Same as Option 2 |
| Thermostatic valve | Design range 1 kelvin | Same as Option 1 | Same as Option 1 |
| Air density validation | Yes | Yes | Yes |
| Thermal bridge validation | No | No | No |
| Heat Generator | District heating (combined heat and power) | Same as Option 1 | Wood pellets |
| Solar support for | Domestic hot water | Same as Option 1 | Same as Option 1 |
| Ventilation | Decentralized exhaust-air plant with heat recovery | Same as Option 1 | Same as Option 1 |

## Energetic results of options

| | | Current building | Option 1: KfW 115 | Option 2: KfW 100 | Option 3: KfW 85 |
|---|---|---|---|---|---|
| **Qp** concerning target value EnEV | < KfW xy in % | 476,28 | 107,97 | 93,61 | 53,19 |
| **H'T** concerning reference building | < KfW (xy+15) in % | 437,80 | 139,50 | 102,70 | 102,70 |
| **H'T** concerning target value EnEV | < 140 % | 357,40 | 113,90 | 83,80 | 83,80 |
| **Qp** (according to EnEV) | [kWh/(m²a)] | 228,60 | 51,80 | 44,90 | 25,50 |
| **H'T** (according to EnEV) | [W/(m²K)] | 1,787 | 0,570 | 0,419 | 0,419 |
| **H'T** (permissible according to EnEV) | [W/(m²K)] | 0,500 | 0,500 | 0,500 | 0,500 |
| **H'T** (reference building) | [W/(m²K)] | 0,408 | 0,408 | 0,408 | 0,408 |
| Specific demand for **heating energy** | [kWh/(m²a)] | 122,40 | 43,00 | 33,60 | 33,60 |
| Specific demand for **final energy** | [kWh/(m²a)] | 174,70 | 62,10 | 52,50 | 75,60 |
| Norm heating load according to DIN 4108-6 | [kW] | 417,30 | 192,20 | 164,40 | 164,40 |

## Building costs

The costs of additional measures are estimated and are stated as pre-tax costs. They need to be checked by a conducting planning office.

## Overview building costs in €

**Buildings costs:**

| | Option 1 | Option 1 | Option 2 | Option 2 | Option 3 | Option 3 |
|---|---|---|---|---|---|---|
| Housing units: | 50 | | 50 | | 50 | |
| Floor size [m²] : | 4.848 | per m² | 4.848 | per m² | 4.848 | per m² |
| Building site equipment | 2.544 € | - | 2.544 € | - | 2.544 € | - |
| Roof | 0 € | 0 € | 0 € | 0 € | 0 € | 0 € |
| Exterior walls | 281.500 € | 181 € | 287.100 € | 184 € | 287.100 € | 184 € |
| Windows | 172.800 € | 439 € | 181.100 € | 459 € | 181.100 € | 459 € |
| Staiway walls | 0 € | 0 € | 0 € | 0 € | 0 € | 0 € |
| Cellar | 0 € | 0 € | 42.900 € | 53 € | 42.900 € | 53 € |
| Installation engineering | 205.500 € | - | 205.500 € | - | 236.800 € | - |
| *Net building costs* | *662.344 €* | | *719.144 €* | | *750.444 €* | |
| Air density validation | 25.000 € | | 25.000 € | | 25.000 € | |
| Thermal bridge validation | 0 € | | 0 € | | 0 € | |
| Additional building costs* 15% | 102.414 € | | 110.877 € | | 115.541 € | |
| *(incl. planning costs, commencement work at building site, …) | | | | | | |
| **All-in cost of building** | **789.759 €** | | **855.022 €** | | **890.985 €** | |
| *corresponds to per m² floor size* | *163 €* | | *176 €* | | *184 €* | |

| **Fictional support*** *(for building being in Germany) | **Option 1** | | **Option 2** | | **Option 3** | |
|---|---|---|---|---|---|---|
| KfW - program: | KfW 115 | | KfW 100 | | KfW 85 | |
| Subsidy: | | | | | | |
| 7,5% | 59.232 € | | | | | |
| 12,5% | | | 106.878 € | | | |
| 15,0% | | | | | 133.648 € | |
| **All-in cost of building <u>past</u> subsidy:** | **<u>730.527 €</u>** | | **<u>748.144 €</u>** | | **<u>757.338 €</u>** | |
| *corresponds to per m² floor size* | *<u>151 €</u>* | | *<u>154 €</u>* | | *<u>156 €</u>* | |

## Overview building costs in BYR

The exchange rate is set to 4.000 BYR/€ and in addition the German costs are reduced by the factor of 0,7 to fit the Belarusian costs.

**Buildings costs:**

| | Option 1 | Option 1 | Option 2 | Option 2 | Option 3 | Option 3 |
|---|---|---|---|---|---|---|
| Housing units: | 50 | | 50 | | 50 | |
| Floor size [m²] : | 4.848 | per m² | 4.848 | per m² | 4.848 | per m² |
| Building site equipment | 7,12 Mio. BYR | - | 7,12 Mio. BYR | - | 7,12 Mio. BYR | - |
| Roof | 0 Mio. BYR | 0 Mio. BYR | 0 Mio. BYR | 0 Mio. BYR | 0 Mio. BYR | 0 Mio. BYR |
| Exterior walls | 788,20 Mio. BYR | 0,506 Mio. BYR | 803,88 Mio. BYR | 0,516 Mio. BYR | 803,88 Mio. BYR | 0,516 Mio. BYR |
| Windows | 483,84 Mio. BYR | 1,228 Mio. BYR | 507,08 Mio. BYR | 1,284 Mio. BYR | 507,08 Mio. BYR | 1,284 Mio. BYR |
| Staiway walls | 0 Mio. BYR | 0 Mio. BYR | 0 Mio. BYR | 0 Mio. BYR | 0 Mio. BYR | 0 Mio. BYR |
| Cellar | 0 Mio. BYR | 0 Mio. BYR | 120,12 Mio. BYR | 0,148 Mio. BYR | 120,12 Mio. BYR | 0,148 Mio. BYR |
| Installation engineering | 575,40 Mio. BYR | - | 575,40 Mio. BYR | - | 663,04 Mio. BYR | - |
| *Net building costs* | *1.855 Mio. BYR* | | *2.014 Mio. BYR* | | *2.101 Mio. BYR* | |
| Air density validation | 70,00 Mio. BYR | | 70,00 Mio. BYR | | 70,00 Mio. BYR | |
| Thermal bridge validation | 0 Mio. BYR | | 0 Mio. BYR | | 0 Mio. BYR | |
| Additional building costs* 15% | 287 Mio. BYR | | 310 Mio. BYR | | 324 Mio. BYR | |
| *(incl. planning costs, commencement work at building site, …) | | | | | | |
| **All-in cost of building** | **2.211 Mio. BYR** | | **2.394 Mio. BYR** | | **2.495 Mio. BYR** | |
| *corresponds to per m² floor size* | *0,456 Mio. BYR* | | *0,494 Mio. BYR* | | *0,515 Mio. BYR* | |
| **Fictional support*** *(for building being in Germany) | **Option 1** | | **Option 2** | | **Option 3** | |
| KfW - program: | KfW 115 | | KfW 100 | | KfW 85 | |
| Subsidy: 7,5% | 166 Mio. BYR | | | | | |
| 12,5% | | | 299 Mio. BYR | | | |
| 15,0% | | | | | 374 Mio. BYR | |
| **All-in cost of building <u>past</u> subsidy:** | **<u>2.045 Mio. BYR</u>** | | **<u>2.095 Mio. BYR</u>** | | **<u>2.121 Mio. BYR</u>** | |
| *corresponds to per m² floor size* | *0,422 Mio. BYR* | | *0,432 Mio. BYR* | | *0,437 Mio. BYR* | |

## Description of assessed building costs

### Costs of installation engineering in €

| Housing units: | 50 | 50 | 50 |
|---|---|---|---|
| Floor size: | 4.848 | 4.848 | 4.848 |
| Floor size per housing unit: | 97,0 | 97,0 | 97,0 |
| | **Option 1** | **Option 2** | **Option 3** |
| **Installation engineering** | | | |
| **Heating** | 30.816 € | 30.816 € | 62.156 € |
| System | District heating (combined heat and power) | District heating (combined heat and power) | Wood pellets |
| Costs new heat generator | 0 € | 0 € | 31.340 € |
| Solar support | 0 € | 0 € | 0 € |
| Distribution system | 0 € | 0 € | 0 € |
| Hydraulic adjustment | 21.816 € | 21.816 € | 21.816 € |
| New valves | 9.000 € | 9.000 € | 9.000 € |
| **Domestic hot water** | 94.697 € | 94.697 € | 94.697 € |
| System | via heating | via heating | via heating |
| Distribution system | 0 € | 0 € | 0 € |
| Hydraulic adjustment | 16.968 € | 16.968 € | 16.968 € |
| Solar support | 67.077 € | 67.077 € | 67.077 € |
| New cistern | 10.652 € | 10.652 € | 10.652 € |
| **Ventilation** | | | |
| System | heat recovery | heat recovery | heat recovery |
| Exhaust-air plant | 79.992 € | 79.992 € | 79.992 € |
| Per housing unit | 1.600 € | 1.600 € | 1.600 € |
| | 205.505 € | 205.505 € | 236.845 € |
| **All-in installation engineering** | **205.500 €** | **205.500 €** | **236.800 €** |

## Costs of installation engineering in BYR

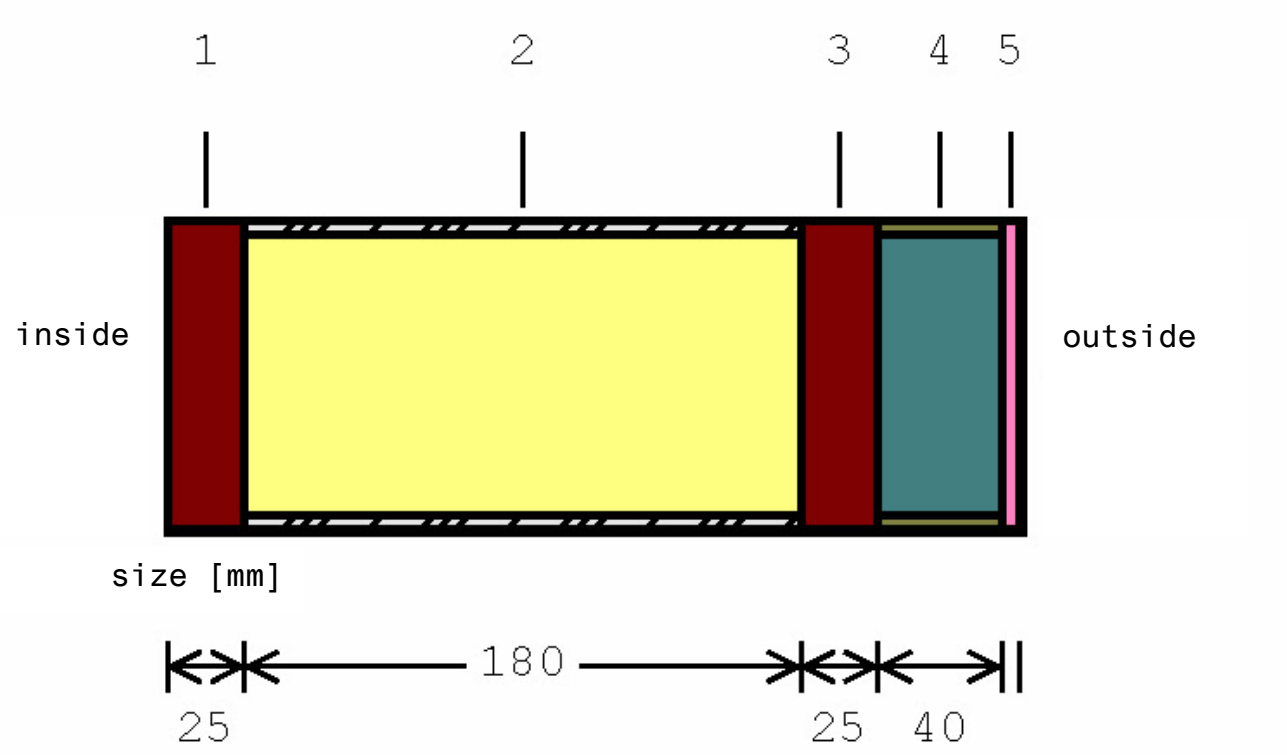
The exchange rate is set to 4.000 BYR/€ and in addition the German costs are reduced by the factor of 0,7 to fit the Belarusian costs.

| Housing units: | **50** | **50** | **50** |
|---|---|---|---|
| Floor size: | 4.848 | 4.848 | 4.848 |
| Floor size per housing unit: | 97,0 | 97,0 | 97,0 |
| | **Option 1** | **Option 2** | **Option 3** |
| **Installation engineering** | | | |
| **Heating** | 86,28 Mio. BYR | 86,28 Mio. BYR | 174,04 Mio. BYR |
| System | District heating (combined heat and power) | District heating (combined heat and power) | Wood pellets |
| Costs new heat generator | 0 Mio. BYR | 0 Mio. BYR | 87,75 Mio. BYR |
| Solar support | 0 Mio. BYR | 0 Mio. BYR | 0 Mio. BYR |
| Distribution system | 0 Mio. BYR | 0 Mio. BYR | 0 Mio. BYR |
| Hydraulic adjustment | 61,08 Mio. BYR | 61,08 Mio. BYR | 61,08 Mio. BYR |
| New valves | 25,20 Mio. BYR | 25,20 Mio. BYR | 25,20 Mio. BYR |
| **Domestic hot water** | 265,15 Mio. BYR | 265,15 Mio. BYR | 265,15 Mio. BYR |
| System | via heating | via heating | via heating |
| Distribution system | 0 Mio. BYR | 0 Mio. BYR | 0 Mio. BYR |
| Hydraulic adjustment | 47,51 Mio. BYR | 47,51 Mio. BYR | 47,51 Mio. BYR |
| Solar support | 187,82 Mio. BYR | 187,82 Mio. BYR | 187,82 Mio. BYR |
| New cistern | 29,82 Mio. BYR | 29,82 Mio. BYR | 29,82 Mio. BYR |
| **Ventilation** | | | |
| System | heat recovery | heat recovery | heat recovery |
| Exhaust-air plant | 223,98 Mio. BYR | 223,98 Mio. BYR | 223,98 Mio. BYR |
| Per housing unit | 4,48 Mio. BYR | 4,48 Mio. BYR | 4,48 Mio. BYR |
| | 575,41 Mio. BYR | 575,41 Mio. BYR | 663,17 Mio. BYR |
| **All-in installation engineering** | **575 Mio. BYR** | **575 Mio. BYR** | **663 Mio. BYR** |

# Appendix

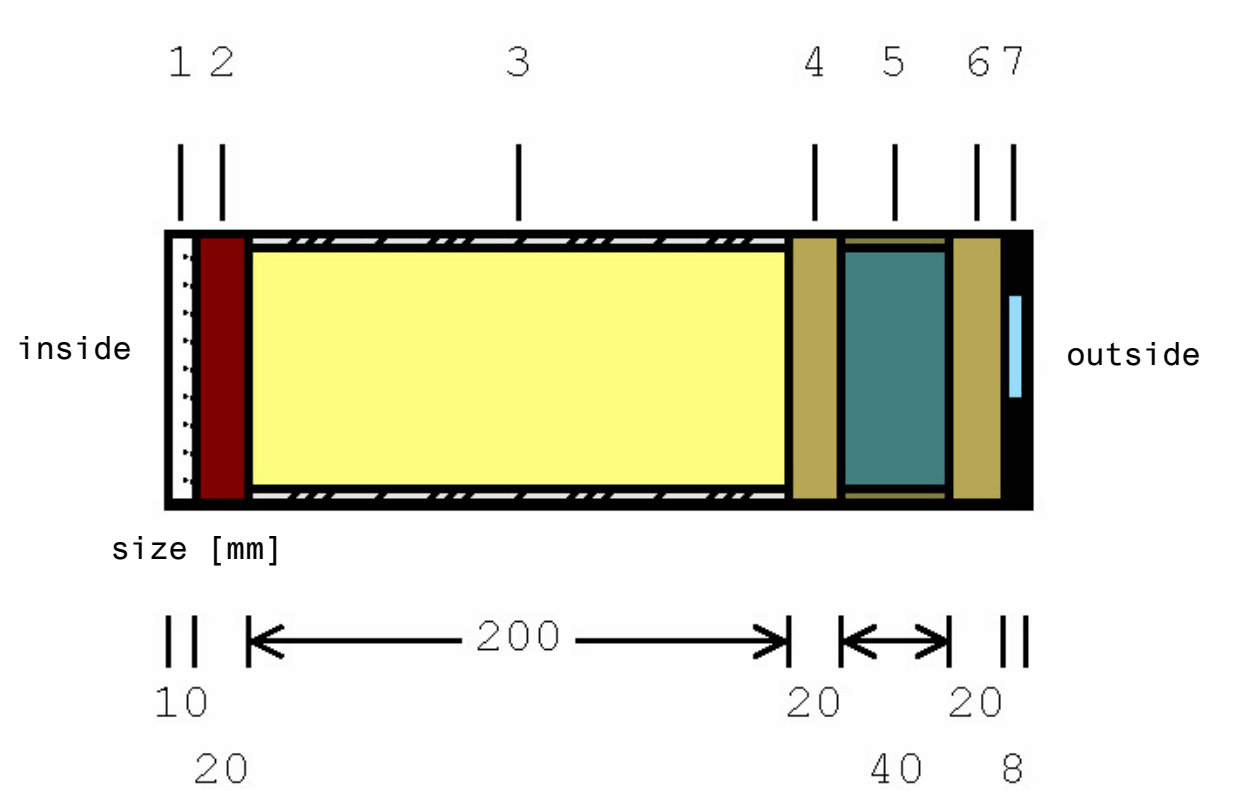
## Appendix 1 - Construction new floor

### Exterior wall




| Layer | Material | Size [mm] | λ [W/mK] | Rate [%] |
|---|---|---|---|---|
| 1 | Engineered wood product: OSB boards | 25 | 0,130 | 100,0 |
| 2 | Mineral rock wool | 180 | 0,042 | 90,0 |
| | Construction wood | 180 | 0,130 | 10,0 |
| 3 | Engineered wood product: OSB boards | 25 | 0,130 | 100,0 |
| 4 | Air | 40 | 0,230 | 90,0 |
| | Soft wood | 40 | 0,090 | 10,0 |
| 5 | Massive plastics: glass fibre (25 %) reinforced polyamide | 5 | 0,300 | 100,0 |

## Roof




| Layer | Material | Size [mm] | λ [W/mK] | Rate [%] |
|---|---|---|---|---|
| 1 | Gypsum plaster board | 10 | 0,250 | 100,0 |
| 2 | Medium density fibreboard (MDF) | 20 | 0,070 | 100,0 |
| 3 | Mineral rock wool | 200 | 0,042 | 90,0 |
| | Construction wood | 200 | 0,130 | 10,0 |
| 4 | Engineered wood product: OSB boards | 20 | 0,130 | 100,0 |
| 5 | Air | 40 | 0,230 | 90,0 |
| | Soft wood | 40 | 0,090 | 10,0 |
| 6 | Engineered wood product: OSB boards | 20 | 0,130 | 100,0 |
| 7 | Bitumen roof sheeting | 8 | 0,170 | 100,0 |

## Appendix 2 - Construction costs new floor

The exchange rate is set to 4.000 BYR/€ and in addition the German costs are reduced by the factor of 0,7 to fit the Belarusian costs.

**Construction costs new floor**

| | [€] total | [€/m²] | [Mio. BYR] total | [BYR/m²] |
|---|---|---|---|---|
| Demolition old roof | 12.200 | 15 | 33,939 | 42.000 |
| Wooden exterior walls | 38.900 | 100 | 108,819 | 280.000 |
| Wooden roof | 88.900 | 110 | 248,889 | 308.000 |
| Floor covering | 20.300 | 25 | 56,566 | 70.000 |
| Windows | 33.000 | 410 | 92,230 | 1.148.000 |
| Additional building costs | 80.000 | 99 | 224,000 | 277.200 |
| | | | | |
| **All-in cost of construction** | **273.300 €** | **759 €/m²** | **764,443 Mio. BYR** | **2,125 Mio. BYR/m²** |

# Appendix 3 - Glossary / Questions

## Primary energy

The energy contained in a fuel before it is processed. It has not been subjected to any conversion or transformation process.

## Final energy

Energy fuels used by final consumers (e.g. households); typically modern final energy forms and fuels are generated involving various steps of conversion from primary energy to final energy.

## Why is option 3 rated better than option 2 with option 3 having a higher conversion loss and less savings than option 2?

The energy-saving measures on both options are the same. They have an equal demand for final energy. The answer for this question is found in the heat generation. The demand for primary energy of option 2 is higher than the one of option 3. District heating is rated worse than wood pellets. District heating is often made of fossil fuels which have to be transported over long distances. Wood pellets are more likely to be produced in a local area and are accounted as renewable energy.

So the answer for the question is the focus of the EnEV on the primary energy and not the final energy. The whole process of energy generation, distribution and consumption is observed.

## 2. Mitskevicha 24

**Investitionsbank** Schleswig-Holstein

**IB.ImmobilienCheck**

**Energetic and economic examination**
Selected energy-saving options
and basis of calculation

Construction project:

**Multi-family House - Energy-saving measures**
Mitskevicha 24
231300 Lida
Belarus

Investor:

Grodno Oblast Executive Committee
Housing Department
230023 Grodno
Belarus


Investitionsbank Schleswig-Holstein

Contact person:

Dipl. Ing. Andreas Dördelmann
Fleethörn 32
24103 Kiel
Germany


Status:

25.03.2010

## Content: Page



## Please note

This document is based on the IB.ImmobilienCheck by the Investitionsbank Schleswig-Holstein. For this project it is extended by information on German framework and energy-saving measures. The first part deals with German framework and terms of energy-saving in general. The second part displays the actual building.

# Part 1 – Information on energy-saving in Germany

## German Energy Saving Ordinance (EnEV)

In Germany the refurbishment of buildings is subject to the German Energy Saving Ordinance.
(German: Energieeinsparverordnung - short: EnEV) The latest version was published in 2009.

**What does the German Energy Saving Ordinance (EnEV) stipulate?**

- Energy performance certificates for buildings.
- Minimum energy requirements for new buildings.
- Minimum energy requirements for modernisation, reconstructions and extensions of existing buildings.
- Minimum requirements for heating, cooling and air-conditioning systems as well as hot-water systems.
- Energy inspection of air-conditioning systems.

**For which buildings does the German Energy Saving Ordinance (EnEV) apply?**

- For all heated and cooled buildings and/or parts of buildings.
- Special stipulations apply for buildings which are not heated, cooled or used regularly (such as holiday homes), which are erected only for a short period of time (such as tents, air halls) or which are used for special purposes, such as stables and greenhouses.
- Small buildings with a floor space of less than 50 m² and historic monuments protected by German land law are not obliged to produce energy performance certificates.

**Requirements for commercial buildings**

Like residential buildings, the requirements for new commercial buildings are defined by the annual primary energy demand. However, in addition to the energy demands for heating, hot water and air conditioning, the balance sheet also includes the proportion of energy for cooling and lighting installations. The new comprehensive calculation method is defined in the new German standard DIN V 18599. The requirements are defined by means of a reference building which corresponds to the real building in terms of geometry, net floor area, orientation and utilisation, but whose technical structure is defined according to Enclosure (2) of the German Energy Saving Ordinance (EnEV). The energy quality of the building cladding and the limitation of the insulation parameter are prescribed as ancillary requirements.

## KfW Banking Group - Financial support program

The KfW Banking Group is a German government-owned development bank. It was formed in 1948 as part of the Marshall Plan. The KfW finances private residential property and environment-friendly measures.

In particular the KfW rewards the efforts of energy-saving in Germany with the "Efficiency House"-program. It supports homeowners in refurbishing their homes concerning energy-saving measures. The program offers low interest financing including subsidy. The subsidy depends on the amount of energy-saving measures and their effects. There are different categories in the "Efficiency House"-program. They are called **KfW 115**, **KfW 100** and **KfW 85**. The names refer to the reference building of the EnEV. The reference building fits the requirements of the EnEV for a new building.

The buildings are classified by two specific values:

- **annual demand for primary energy**

  This value $\mathbf{Q_p}$ shows the demand for primary energy of the building compared to the demand of the EnEV reference building in percent.
- **transmission heat loss**

  This value **H'T** shows the heat loss through the building envelope compared to the heat loss of the EnEV reference building.

For example: A building still fits the requirements of the KfW 115 category if it has up to 15 % more demand for primary energy than the reference building.

## Energy-saving measures in Lida

We evaluated the volume and the floor size and generated models of the buildings in Lida. The rating of these models bases on German standards for refurbishing houses. The different options calculated fit the requirements of the German support program by the KfW Banking Group.

The generated model of the current building forms the basis of our calculation. To reach the different target values of the KfW program we developed different options concerning energy-saving measures. In these options we took care of the construction components at first. With replacements and insulation we reduced the transmission heat loss and the demand for primary energy. Second we replaced the heat generation which reduced the demand for primary energy of the options.

To reach the German standards there have to be made substantial changes in the heat generation of the buildings. District heating and wood pellets may not be available on site. For this it is advised to accomplish the non-installation engineering measures first. The technical installations (such as district heating and wood pellets) should be done after.

## Specific information on building - Mitskevicha 24

To fit the German standards we needed to replace the heat generator. In Option 1 and 2 we changed the supply of the district heating system from heating only to cogeneration of heat and power. This is beyond the energy efficient measures so we did not consider the costs for this change in our calculations.

Compared to other components measures concerning the roof were less efficient in our calculations even though it could be advisable to refurbish the roof, too. In this case please mind that the roof sheeting (bitumen or plastics) has to be done multilayered and smoothly. Also pay attention to the down-grade of the roof (at least 2 %) so you avoid long term damage caused by water.

## Agenda - What to do

The following list of priority shows what is to be done in which order. Between the first and the second phase should be enough time to measure the new demand for heat energy.

To ensure the quality of the energy-saving measures please mind the information given in the third chapter of the attached dena "Handbook for energy refurbishment of residential buildings in the Russian federation" in Russian language.

### First phase

1. Commencement of work at building site
2. Energy-saving measures of the building envelope
   a. Replacement of the entrance doors and the windows
   b. Insulation of the exterior walls
   c. Insulation of the basement

### Second Phase

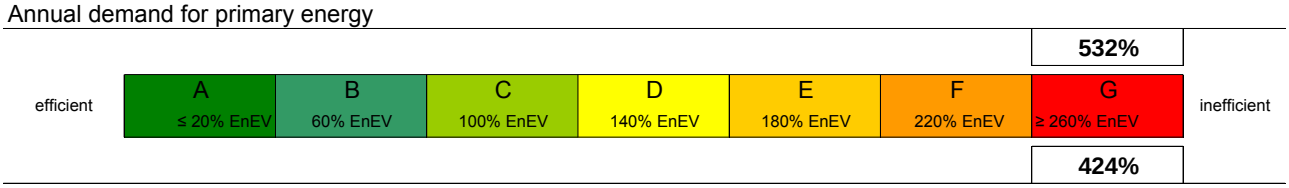
3. Measuring the new demand for heat energy on basis of the new requirement
4. Sizing and choosing the new heat generator
5. Installation of the new heat generator and additional technical components (heating, domestic hot water, ventilation)

# Part 2 – Energetic Examination

## Benchmark of current building

Examination of the current building compared to the target value of EnEV 2009

Annual demand for primary energy

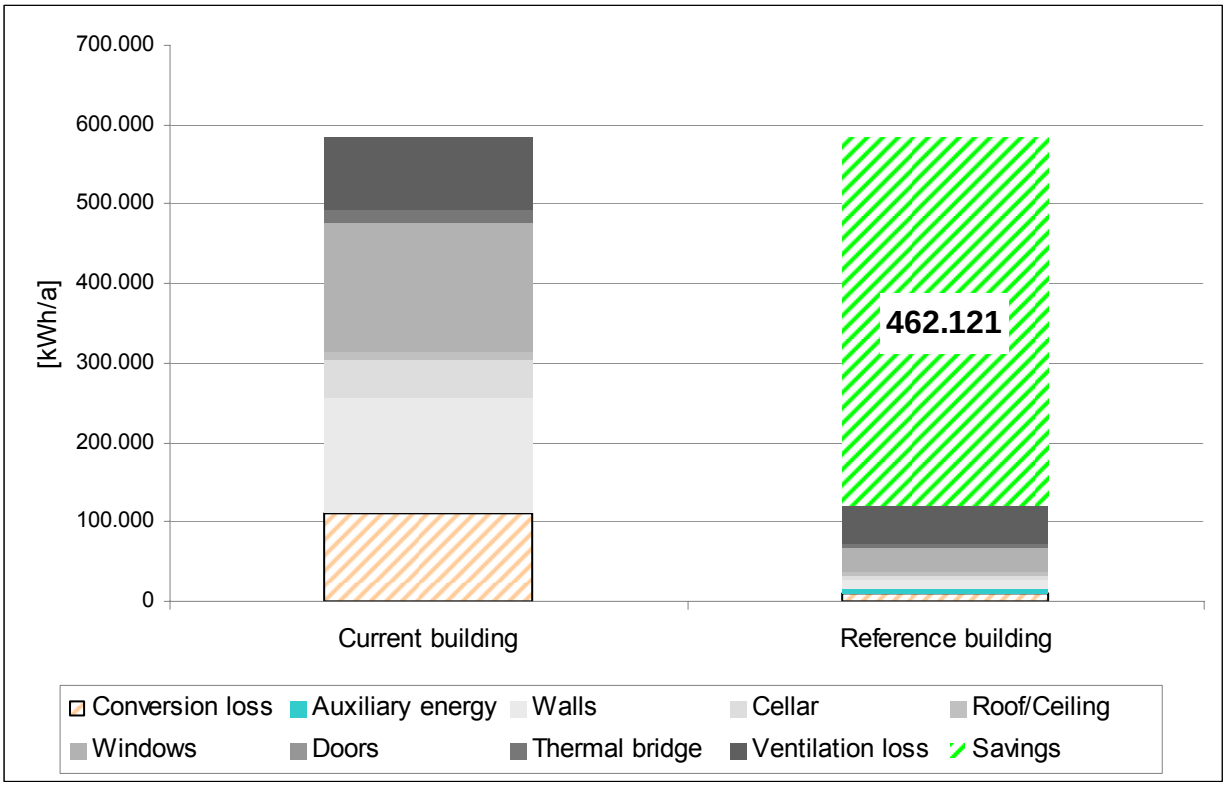



Transmission heat loss

## Rating of present heat loss

Overview of heat loss of the current building divided into construction components and technical installations.

For the purpose of comparison a reference building is shown. It matches the current building in form and cubature and fits the target values of EnEV 2009.




*Conclusion:*

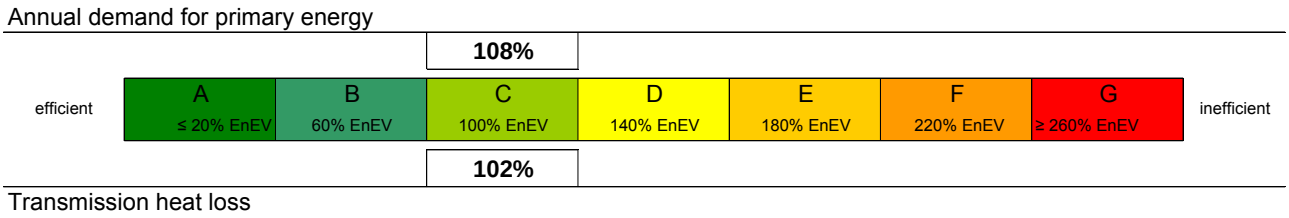
The building offers for all construction components the potential for energy-saving measures. Implementing these measures is going to lead to a reduction of transmission heat loss. As a result the heat generator will be oversized. This means a needless increase in stand-by losses. It is advisable the install a new heat generator fitting the new demand of heating energy.

## Selected energy-saving options

In Germany the KfW Banking Group rewards energy-saving measures.
The following options include the financial support of the KfW.

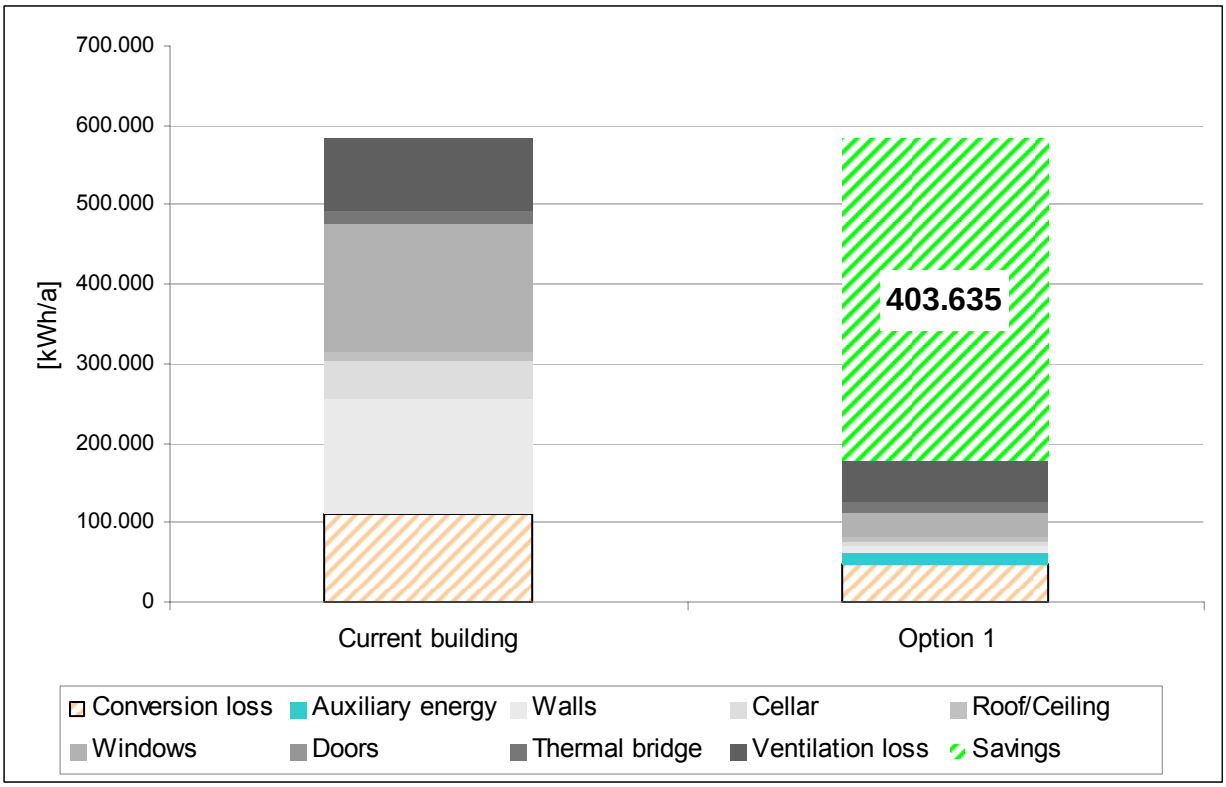
### Option 1: KfW 115

Classification of the energetic quality is based on the target values of EnEV 2009.




*Measures:*

- Insulation exterior wall (14 cm, thermal insulation composite system 035)
- Replacement Windows (Thermal transmission coefficient = 1,3 [W/(m²K)] )
- Replacement entrance doors (Thermal transmission coefficient = 2,0 [W/(m²K)] )
- Replacement heat generator (district heating, combined heat and power, fossil fuel)
- Installation solar domestic hot water with a bivalent cistern
- Installation decentralized exhaust-air plant with heat recovery and air density validation
- Replacement thermostatic valve (design range 1 kelvin)
- Insulation basement (8 cm, thermal insulation composite system 025)

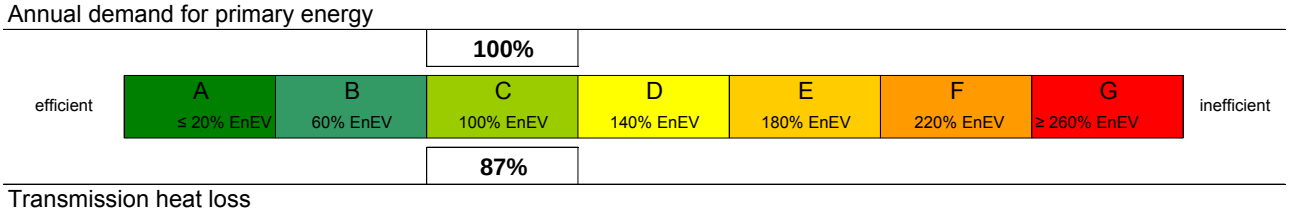



*Financing:*

- Support program: KfW - Energy-Efficient Rehabilitation, *Efficiency House 115*
- Conditions: low interest financing incl. subsidy in the amount of 7,5%

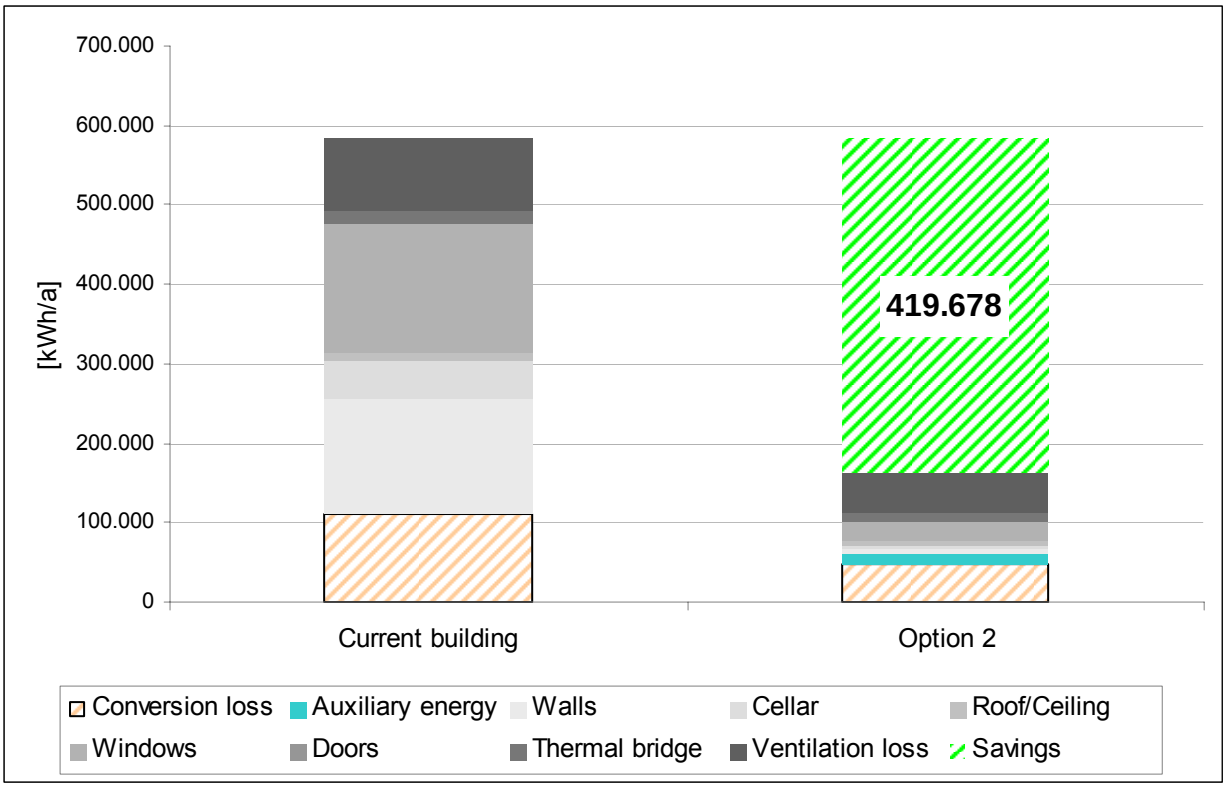
## Option 2: KfW 100

Classification of the energetic quality is based on the target values of EnEV 2009.




### *Measures:*

- Insulation exterior wall (24 cm, thermal insulation composite system 035)
- Replacement Windows (Thermal transmission coefficient = 1,1 [W/(m²K)] )
- Replacement entrance doors (Thermal transmission coefficient = 1,8 [W/(m²K)] )
- Replacement heat generator (district heating, combined heat and power, fossil fuel)
- Installation solar domestic hot water with a bivalent cistern
- Installation decentralized exhaust-air plant with heat recovery and air density validation
- Replacement thermostatic valve (design range 1 kelvin)
- Insulation basement (12 cm, thermal insulation composite system 025)

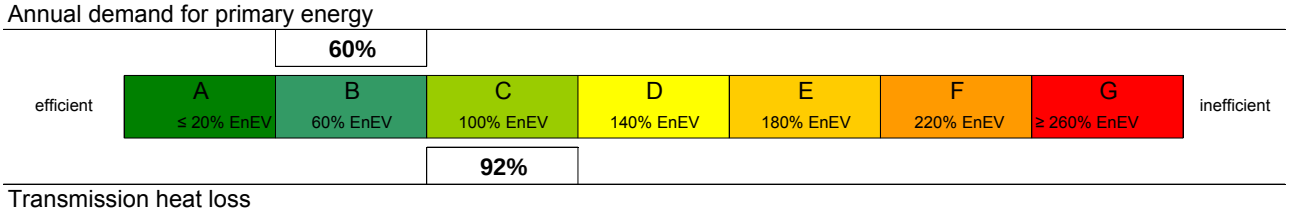



### *Financing:*

- Support program: KfW - Energy-Efficient Rehabilitation, *Efficiency House 100*
- Conditions: low interest financing incl. subsidy in the amount of 12,5%

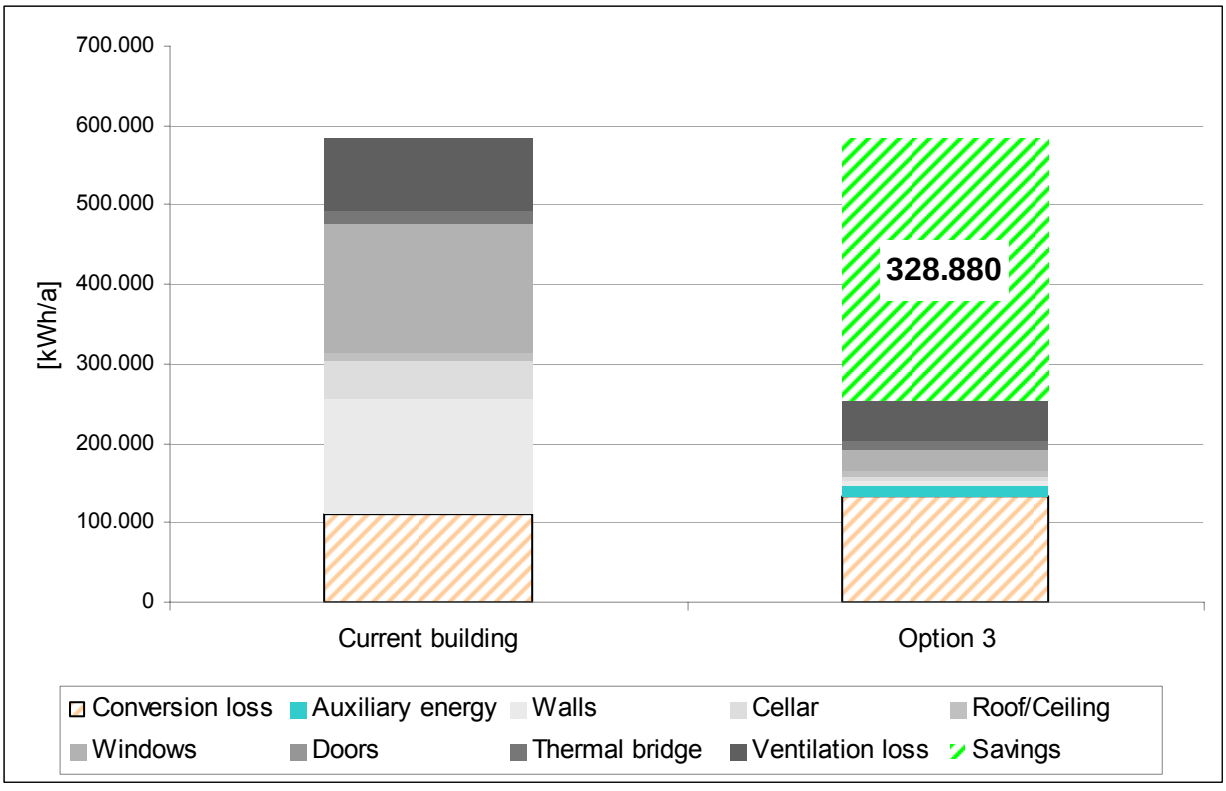
## Option 3: KfW 85

Classification of the energetic quality is based on the target values of EnEV 2009.




### *Measures:*

- Insulation exterior wall (18 cm, thermal insulation composite system 035)
- Replacement Windows (Thermal transmission coefficient = 1,1 [W/(m²K)] )
- Replacement entrance doors (Thermal transmission coefficient = 1,8 [W/(m²K)] )
- New heat generator (wood pellets)
- Installation solar domestic hot water with a bivalent cistern
- Installation decentralized exhaust-air plant with heat recovery and air density validation
- Replacement thermostatic valve (design range 1 kelvin)
- Insulation basement (8 cm, thermal insulation composite system 035)




### *Financing:*

- Support program: KfW - Energy-Efficient Rehabilitation, *Efficiency House 85*
- Conditions: low interest financing incl. subsidy in the amount of 15%

# Overview options

## Energy-saving measures

| Construction component | Option 1 | Option 2 | Option 3 |
|---|---|---|---|
| *KfW program*<br>*Subsidy* | Efficiency House 115<br>7,5% | Efficiency House 100<br>12,5% | Efficiency House 85<br>15% |
| | | | |
| Exterior wall | 14 cm (035) | 24 cm (035) | 18 cm (035) |
| Entrance doors | 2,0 [W/(m²K)] | 1,8 [W/(m²K)] | Same as Option 2 |
| Windows | 1,3 [W/(m²K)] | 1,1 [W/(m²K)] | Same as Option 2 |
| Basement | 8 cm (025) | 12 cm (025) | Same as Option 1 |
| Thermostatic valve | Design range 1 kelvin | Same as Option 1 | Same as Option 1 |
| Air density validation | Yes | Yes | Yes |
| Thermal bridge validation | No | No | No |
| Heat Generator | District heating (combined heat and power) | Same as Option 1 | Wood pellets |
| Solar support for | Domestic hot water | Same as Option 1 | Same as Option 1 |
| Ventilation | Decentralized exhaust-air plant with heat recovery | Same as Option 1 | Same as Option 1 |

## Energetic results of options

| | | Current building | Option 1: KfW 115 | Option 2: KfW 100 | Option 3: KfW 85 |
|---|---|---|---|---|---|
| **Qp** concerning target value EnEV | < KfW xy in % | 532,45 | 107,75 | 99,69 | 60,38 |
| **H'T** concerning reference building | < KfW (xy+15) in % | 451,10 | 109,00 | 92,70 | 98,10 |
| **H'T** concerning target value EnEV | < 140 % | 423,90 | 102,40 | 87,10 | 92,20 |
| **Qp** (according to EnEV) | [kWh/(m²a)] | 218,20 | 44,20 | 40,90 | 24,80 |
| **H'T** (according to EnEV) | [W/(m²K)] | 2,120 | 0,512 | 0,435 | 0,461 |
| **H'T** (permissible according to EnEV) | [W/(m²K)] | 0,500 | 0,500 | 0,500 | 0,500 |
| **H'T** (reference building) | [W/(m²K)] | 0,470 | 0,470 | 0,470 | 0,470 |
| Specific demand for **heating energy** | [kWh/(m²a)] | 126,40 | 28,50 | 23,90 | 25,40 |
| Specific demand for **final energy** | [kWh/(m²a)] | 167,60 | 51,60 | 47,00 | 73,10 |
| Norm heating load according to DIN 4108-6 | [kW] | 367,10 | 128,80 | 117,40 | 121,20 |

## Building costs

The costs of additional measures are estimated and are stated as pre-tax costs. They need to be checked by a conducting planning office.

## Overview building costs in €

**Buildings costs:**

| | Option 1 | Option 1 | Option 2 | Option 2 | Option 3 | Option 3 |
|---|---|---|---|---|---|---|
| Housing units: | 60 | | 60 | | 60 | |
| Floor size [m²] : | 3.808 | per m² | 3.808 | per m² | 3.808 | per m² |
| Building site equipment | 2.544 € | - | 2.544 € | - | 2.544 € | - |
| Roof | 0 € | 0 € | 0 € | 0 € | 0 € | 0 € |
| Exterior walls | 199.300 € | 181 € | 209.200 € | 190 € | 203.200 € | 184 € |
| Windows | 236.100 € | 439 € | 247.400 € | 459 € | 247.400 € | 459 € |
| Staiway walls | 0 € | 0 € | 0 € | 0 € | 0 € | 0 € |
| Cellar | 34.300 € | 45 € | 38.100 € | 50 € | 34.300 € | 45 € |
| Installation engineering | 181.800 € | - | 181.800 € | - | 213.200 € | - |
| *Net building costs* | *654.044 €* | | *679.044 €* | | *700.644 €* | |
| Air density validation | 30.000 € | | 30.000 € | | 30.000 € | |
| Thermal bridge validation | 0 € | | 0 € | | 0 € | |
| Additional building costs* 15% | 101.923 € | | 105.648 € | | 108.866 € | |
| *(incl. planning costs, commencement work at building site, …) | | | | | | |
| **All-in cost of building** | **785.967 €** | | **814.692 €** | | **839.510 €** | |
| *corresponds to per m² floor size* | *206 €* | | *214 €* | | *220 €* | |

| **Fictional support*** *(for building being in Germany) | **Option 1** | | **Option 2** | | **Option 3** | |
|---|---|---|---|---|---|---|
| KfW - program: | KfW 115 | | KfW 100 | | KfW 85 | |
| Subsidy: | | | | | | |
| 7,5% | 58.948 € | | | | | |
| 12,5% | | | 101.836 € | | | |
| 15,0% | | | | | 125.927 € | |
| **All-in cost of building past subsidy:** | **727.019 €** | | **712.855 €** | | **713.584 €** | |
| *corresponds to per m² floor size* | *191 €* | | *187 €* | | *187 €* | |

## Overview building costs in BYR

The exchange rate is set to 4.000 BYR/€ and in addition the German costs are reduced by the factor of 0,7 to fit the Belarusian costs.

**Buildings costs:**

| | | Option 1 | Option 1 | Option 2 | Option 2 | Option 3 | Option 3 |
|---|---|---|---|---|---|---|---|
| Housing units: | | 60 | | 60 | | 60 | |
| Floor size [m²] : | | 3.808 | per m² | 3.808 | per m² | 3.808 | per m² |
| Building site equipment | | 7,12 Mio. BYR | - | 7,12 Mio. BYR | - | 7,12 Mio. BYR | - |
| Roof | | 0 Mio. BYR | 0 Mio. BYR | 0 Mio. BYR | 0 Mio. BYR | 0 Mio. BYR | 0 Mio. BYR |
| Exterior walls | | 558,04 Mio. BYR | 0,506 Mio. BYR | 585,76 Mio. BYR | 0,531 Mio. BYR | 568,96 Mio. BYR | 0,516 Mio. BYR |
| Windows | | 661,08 Mio. BYR | 1,228 Mio. BYR | 692,72 Mio. BYR | 1,284 Mio. BYR | 692,72 Mio. BYR | 1,284 Mio. BYR |
| Staiway walls | | 0 Mio. BYR | 0 Mio. BYR | 0 Mio. BYR | 0 Mio. BYR | 0 Mio. BYR | 0 Mio. BYR |
| Cellar | | 96 Mio. BYR | 0 Mio. BYR | 106,68 Mio. BYR | 0,140 Mio. BYR | 96,04 Mio. BYR | 0,126 Mio. BYR |
| Installation engineering | | 509,04 Mio. BYR | - | 509,04 Mio. BYR | - | 596,96 Mio. BYR | - |
| *Net building costs* | | *1.831 Mio. BYR* | | *1.901 Mio. BYR* | | *1.962 Mio. BYR* | |
| Air density validation | | 84,00 Mio. BYR | | 84,00 Mio. BYR | | 84,00 Mio. BYR | |
| Thermal bridge validation | | 0 Mio. BYR | | 0 Mio. BYR | | 0 Mio. BYR | |
| Additional building costs* | 15% | 285 Mio. BYR | | 296 Mio. BYR | | 305 Mio. BYR | |
| *(incl. planning costs, commencement work at building site, …) | | | | | | | |
| **All-in cost of building** | | **2.201 Mio. BYR** | | **2.281 Mio. BYR** | | **2.351 Mio. BYR** | |
| *corresponds to per m² floor size* | | *0,578 Mio. BYR* | | *0,599 Mio. BYR* | | *0,617 Mio. BYR* | |
| | | | | | | | |
| **Fictional support*** *(for building being in Germany) | | **Option 1** | | **Option 2** | | **Option 3** | |
| KfW - program: | | KfW 115 | | KfW 100 | | KfW 85 | |
| Subsidy: | | | | | | | |
| 7,5% | | 165 Mio. BYR | | | | | |
| 12,5% | | | | 285 Mio. BYR | | | |
| 15,0% | | | | | | 353 Mio. BYR | |
| **All-in cost of building <u>past</u> subsidy:** | | **<u>2.036 Mio. BYR</u>** | | **<u>1.996 Mio. BYR</u>** | | **<u>1.998 Mio. BYR</u>** | |
| *corresponds to per m² floor size* | | *<u>0,535 Mio. BYR</u>* | | *<u>0,524 Mio. BYR</u>* | | *<u>0,525 Mio. BYR</u>* | |

## Description of assessed building costs

### Costs of installation engineering in €

| Housing units: | 60 | 60 | 60 |
|---|---|---|---|
| Floor size: | 3.808 | 3.808 | 3.808 |
| Floor size per housing unit: | 63,5 | 63,5 | 63,5 |
| | **Option 1** | **Option 2** | **Option 3** |
| **Installation engineering** | | | |
| **Heating** | 27.936 € | 27.936 € | 59.276 € |
| System | District heating (combined heat and power) | District heating (combined heat and power) | Wood pellets |
| Costs new heat generator | 0 € | 0 € | 31.340 € |
| Solar support | 0 € | 0 € | 0 € |
| Distribution system | 0 € | 0 € | 0 € |
| Hydraulic adjustment | 17.136 € | 17.136 € | 17.136 € |
| New valves | 10.800 € | 10.800 € | 10.800 € |
| **Domestic hot water** | 91.057 € | 91.057 € | 91.057 € |
| System | via heating | via heating | via heating |
| Distribution system | 0 € | 0 € | 0 € |
| Hydraulic adjustment | 13.328 € | 13.328 € | 13.328 € |
| Solar support | 67.077 € | 67.077 € | 67.077 € |
| New cistern | 10.652 € | 10.652 € | 10.652 € |
| **Ventilation** | | | |
| System | heat recovery | heat recovery | heat recovery |
| Exhaust-air plant | 62.832 € | 62.832 € | 62.832 € |
| Per housing unit | 1.047 € | 1.047 € | 1.047 € |
| | 181.825 € | 181.825 € | 213.165 € |
| **All-in installation engineering** | **181.800 €** | **181.800 €** | **213.200 €** |

## Costs of installation engineering in BYR

The exchange rate is set to 4.000 BYR/€ and in addition the German costs are reduced by the factor of 0,7 to fit the Belarusian costs.

| Housing units: | **60** | **60** | **60** |
|---|---|---|---|
| Floor size: | 3.808 | 3.808 | 3.808 |
| Floor size per housing unit: | 63,5 | 63,5 | 63,5 |
| | **Option 1** | **Option 2** | **Option 3** |
| **Installation engineering** | | | |
| **Heating** | 78,22 Mio. BYR | 78,22 Mio. BYR | 165,97 Mio. BYR |
| System | District heating (combined heat and power) | District heating (combined heat and power) | Wood pellets |
| Costs new heat generator | 0 Mio. BYR | 0 Mio. BYR | 87,75 Mio. BYR |
| Solar support | 0 Mio. BYR | 0 Mio. BYR | 0 Mio. BYR |
| Distribution system | 0 Mio. BYR | 0 Mio. BYR | 0 Mio. BYR |
| Hydraulic adjustment | 47,98 Mio. BYR | 47,98 Mio. BYR | 47,98 Mio. BYR |
| New valves | 30,24 Mio. BYR | 30,24 Mio. BYR | 30,24 Mio. BYR |
| **Domestic hot water** | 254,96 Mio. BYR | 254,96 Mio. BYR | 254,96 Mio. BYR |
| System | via heating | via heating | via heating |
| Distribution system | 0 Mio. BYR | 0 Mio. BYR | 0 Mio. BYR |
| Hydraulic adjustment | 37,32 Mio. BYR | 37,32 Mio. BYR | 37,32 Mio. BYR |
| Solar support | 187,82 Mio. BYR | 187,82 Mio. BYR | 187,82 Mio. BYR |
| New cistern | 29,82 Mio. BYR | 29,82 Mio. BYR | 29,82 Mio. BYR |
| **Ventilation** | | | |
| System | heat recovery | heat recovery | heat recovery |
| Exhaust-air plant | 175,93 Mio. BYR | 175,93 Mio. BYR | 175,93 Mio. BYR |
| Per housing unit | 2,93 Mio. BYR | 2,93 Mio. BYR | 2,93 Mio. BYR |
| | 509,11 Mio. BYR | 509,11 Mio. BYR | 596,86 Mio. BYR |
| **All-in installation engineering** | **509 Mio. BYR** | **509 Mio. BYR** | **597 Mio. BYR** |

# Appendix 1 - Glossary / Questions

## Primary energy

The energy contained in a fuel before it is processed. It has not been subjected to any conversion or transformation process.

## Final energy

Energy fuels used by final consumers (e.g. households); typically modern final energy forms and fuels are generated involving various steps of conversion from primary energy to final energy.

## Why is option 3 rated better than option 2 with option 3 having a higher conversion loss and less savings than option 2?

The energy-saving measures on both options are the same. They have an equal demand for final energy. The answer for this question is found in the heat generation. The demand for primary energy of option 2 is higher than the one of option 3. District heating is rated worse than wood pellets. District heating is often made of fossil fuels which have to be transported over long distances. Wood pellets are more likely to be produced in a local area and are accounted as renewable energy.

So the answer for the question is the focus of the EnEV on the primary energy and not the final energy. The whole process of energy generation, distribution and consumption is observed.

## 3. Tavlaya 35

**Investitionsbank** Schleswig-Holstein

**IB.ImmobilienCheck**

**Energetic and economic examination**
Selected energy-saving options
and basis of calculation

Construction project:

**Multi-family House - Energy-saving measures**
Tavlaya 35
231300 Lida
Belarus

Investor:

Grodno Oblast Executive Committee
Housing Department
230023 Grodno
Belarus


Investitionsbank Schleswig-Holstein

Contact person:

Dipl. Ing. Andreas Dördelmann
Fleethörn 32
24103 Kiel
Germany


Status:

26.03.2010

## Content: Page



## Please note

This document is based on the IB.ImmobilienCheck by the Investitionsbank Schleswig-Holstein. For this project it is extended by information on German framework and energy-saving measures. The first part deals with German framework and terms of energy-saving in general. The second part displays the actual building.

# Part 1 – Information on energy-saving in Germany

## German Energy Saving Ordinance (EnEV)

In Germany the refurbishment of buildings is subject to the German Energy Saving Ordinance.
(German: Energieeinsparverordnung - short: EnEV) The latest version was published in 2009.

**What does the German Energy Saving Ordinance (EnEV) stipulate?**

- Energy performance certificates for buildings.
- Minimum energy requirements for new buildings.
- Minimum energy requirements for modernisation, reconstructions and extensions of existing buildings.
- Minimum requirements for heating, cooling and air-conditioning systems as well as hot-water systems.
- Energy inspection of air-conditioning systems.

**For which buildings does the German Energy Saving Ordinance (EnEV) apply?**

- For all heated and cooled buildings and/or parts of buildings.
- Special stipulations apply for buildings which are not heated, cooled or used regularly (such as holiday homes), which are erected only for a short period of time (such as tents, air halls) or which are used for special purposes, such as stables and greenhouses.
- Small buildings with a floor space of less than 50 m² and historic monuments protected by German land law are not obliged to produce energy performance certificates.

**Requirements for commercial buildings**

Like residential buildings, the requirements for new commercial buildings are defined by the annual primary energy demand. However, in addition to the energy demands for heating, hot water and air conditioning, the balance sheet also includes the proportion of energy for cooling and lighting installations. The new comprehensive calculation method is defined in the new German standard DIN V 18599. The requirements are defined by means of a reference building which corresponds to the real building in terms of geometry, net floor area, orientation and utilisation, but whose technical structure is defined according to Enclosure (2) of the German Energy Saving Ordinance (EnEV). The energy quality of the building cladding and the limitation of the insulation parameter are prescribed as ancillary requirements.

## KfW Banking Group - Financial support program

The KfW Banking Group is a German government-owned development bank. It was formed in 1948 as part of the Marshall Plan. The KfW finances private residential property and environment-friendly measures.

In particular the KfW rewards the efforts of energy-saving in Germany with the "Efficiency House"-program. It supports homeowners in refurbishing their homes concerning energy-saving measures. The program offers low interest financing including subsidy. The subsidy depends on the amount of energy-saving measures and their effects. There are different categories in the "Efficiency House"-program. They are called **KfW 115**, **KfW 100** and **KfW 85**. The names refer to the reference building of the EnEV. The reference building fits the requirements of the EnEV for a new building.

The buildings are classified by two specific values:

- **annual demand for primary energy**

  This value $\mathbf{Q_p}$ shows the demand for primary energy of the building compared to the demand of the EnEV reference building in percent.
- **transmission heat loss**

  This value **H'T** shows the heat loss through the building envelope compared to the heat loss of the EnEV reference building.

For example: A building still fits the requirements of the KfW 115 category if it has up to 15 % more demand for primary energy than the reference building.

## Energy-saving measures in Lida

We evaluated the volume and the floor size and generated models of the buildings in Lida. The rating of these models bases on German standards for refurbishing houses. The different options calculated fit the requirements of the German support program by the KfW Banking Group.

The generated model of the current building forms the basis of our calculation. To reach the different target values of the KfW program we developed different options concerning energy-saving measures. In these options we took care of the construction components at first. With replacements and insulation we reduced the transmission heat loss and the demand for primary energy. Second we replaced the heat generation which reduced the demand for primary energy of the options.

To reach the German standards there have to be made substantial changes in the heat generation of the buildings. District heating and wood pellets may not be available on site. For this it is advised to accomplish the non-installation engineering measures first. The technical installations (such as district heating and wood pellets) should be done after.

## Specific information on building - Tavlaya 35

To fit the German standards we needed to replace the heat generator. In Option 1 and 2 we changed the supply of the district heating system from heating only to cogeneration of heat and power. This is beyond the energy efficient measures so we did not consider the costs for this change in our calculations.

Compared to other components measures concerning the roof were less efficient in our calculations even though it could be advisable to refurbish the roof, too. In this case please mind that the roof sheeting (bitumen or plastics) has to be done multilayered and smoothly. Also pay attention to the down-grade of the roof (at least 2 %) so you avoid long term damage caused by water.

## Agenda - What to do

The following list of priority shows what is to be done in which order. Between the first and the second phase should be enough time to measure the new demand for heat energy.

To ensure the quality of the energy-saving measures please mind the information given in the third chapter of the attached dena "Handbook for energy refurbishment of residential buildings in the Russian federation" in Russian language.

### First phase

1. Commencement of work at building site
2. Energy-saving measures of the building envelope
   a. Replacement of the entrance doors and the windows
   b. Insulation of the exterior walls
   c. Insulation of the basement

### Second Phase

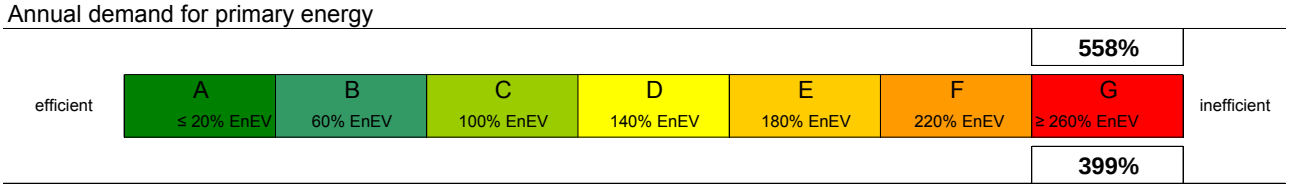
3. Measuring the new demand for heat energy on basis of the new requirement
4. Sizing and choosing the new heat generator
5. Installation of the new heat generator and additional technical components (heating, domestic hot water, ventilation)

# Part 2 – Energetic Examination

## Benchmark of current building

Examination of the current building compared to the target value of EnEV 2009

Annual demand for primary energy

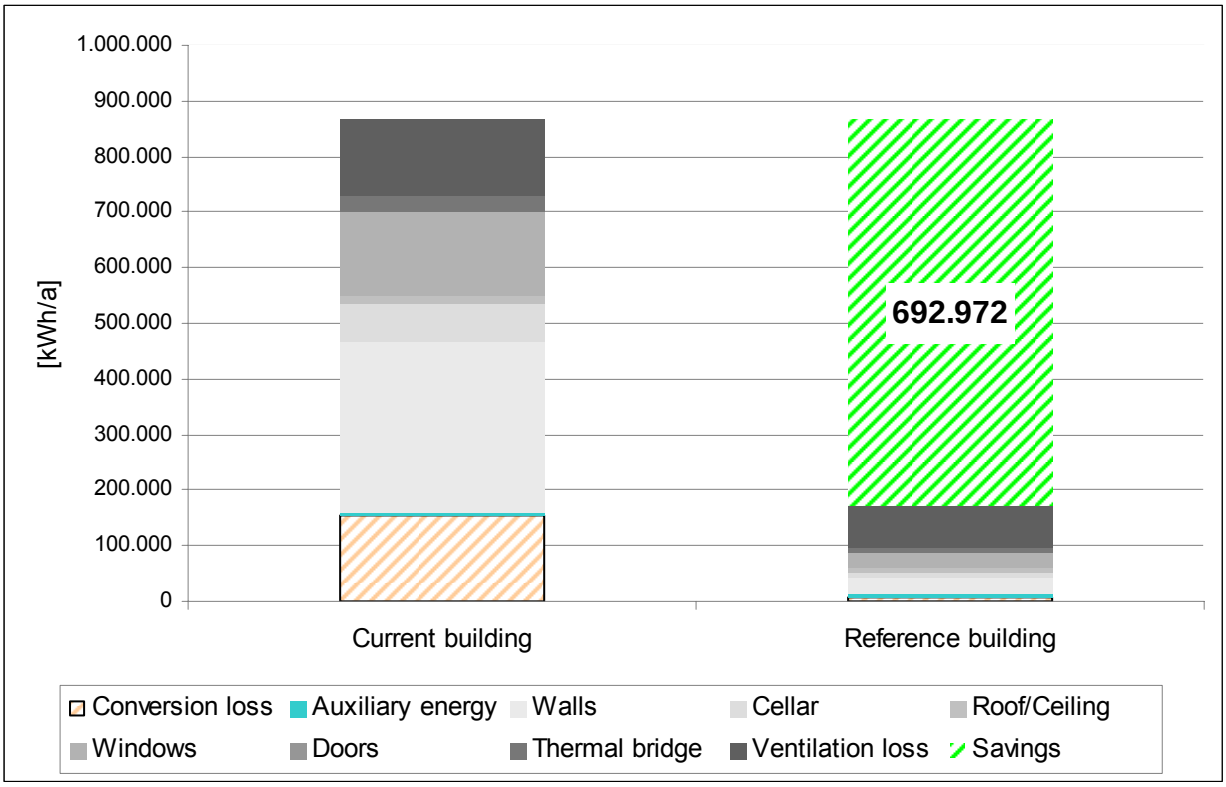



Transmission heat loss

## Rating of present heat loss

Overview of heat loss of the current building divided into construction components and technical installations.

For the purpose of comparison a reference building is shown. It matches the current building in form and cubature and fits the target values of EnEV 2009.




*Conclusion:*

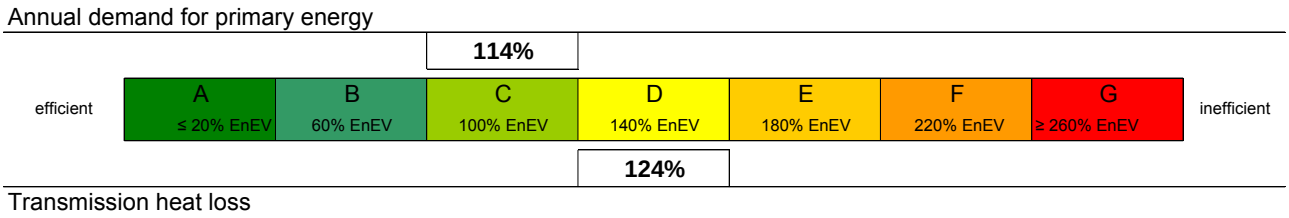
The building offers for all construction components the potential for energy-saving measures. Implementing these measures is going to lead to a reduction of transmission heat loss. As a result the heat generator will be oversized. This means a needless increase in stand-by losses. It is advisable the install a new heat generator fitting the new demand of heating energy.

## Selected energy-saving options

In Germany the KfW Banking Group rewards energy-saving measures.
The following options include the financial support of the KfW.

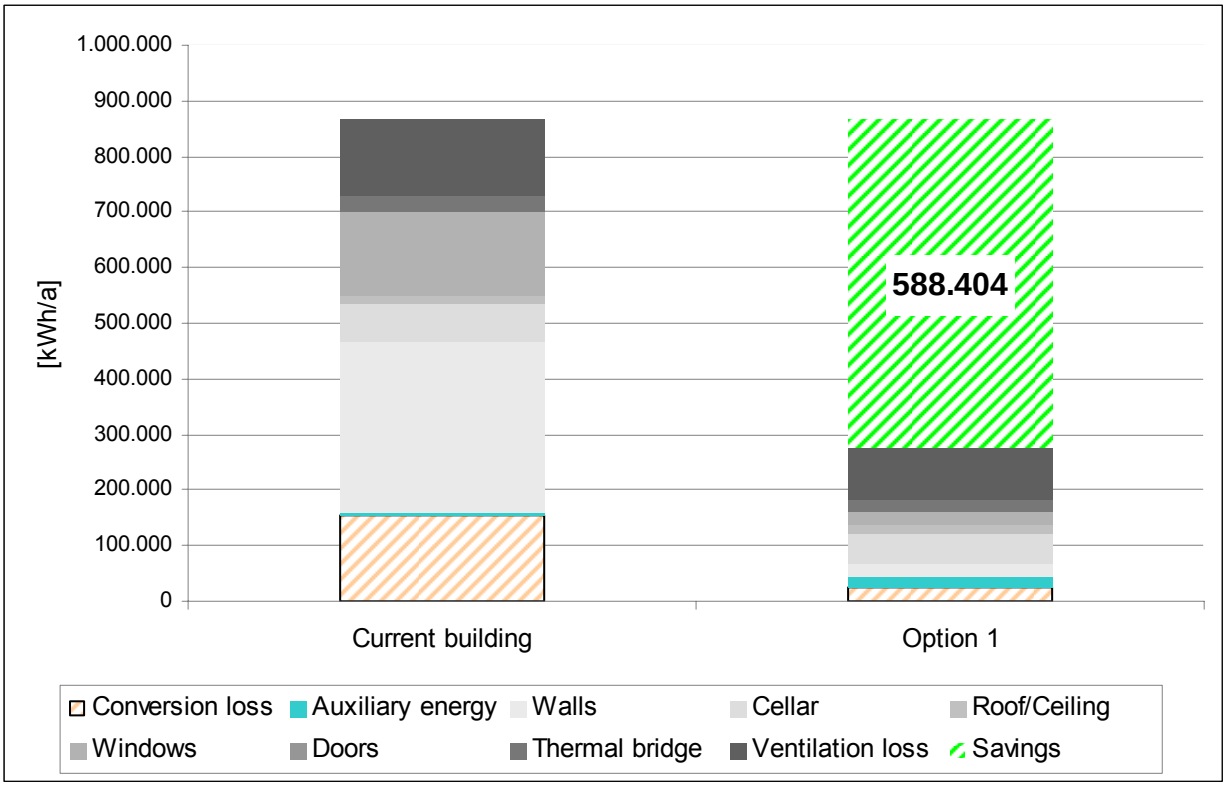
### Option 1: KfW 115

Classification of the energetic quality is based on the target values of EnEV 2009.




*Measures:*

- Insulation exterior wall (14 cm, thermal insulation composite system 035)
- Replacement Windows (Thermal transmission coefficient = 1,1 [W/(m²K)] )
- Replacement entrance doors (Thermal transmission coefficient = 2,0 [W/(m²K)] )
- Replacement heat generator (district heating, combined heat and power, fossil fuel)
- Installation solar domestic hot water with a bivalent cistern
- Installation decentralized exhaust-air plant with heat recovery and air density validation
- Replacement thermostatic valve (design range 1 kelvin)



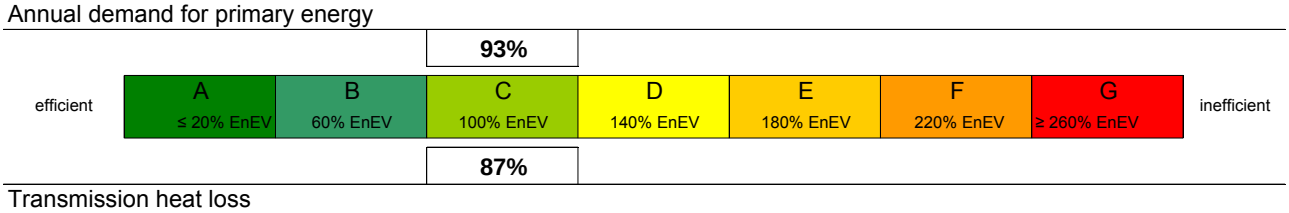

*Financing:*

- Support program: KfW - Energy-Efficient Rehabilitation, *Efficiency House 115*
- Conditions: low interest financing incl. subsidy in the amount of 7,5%

## Option 2: KfW 100

Classification of the energetic quality is based on the target values of EnEV 2009.

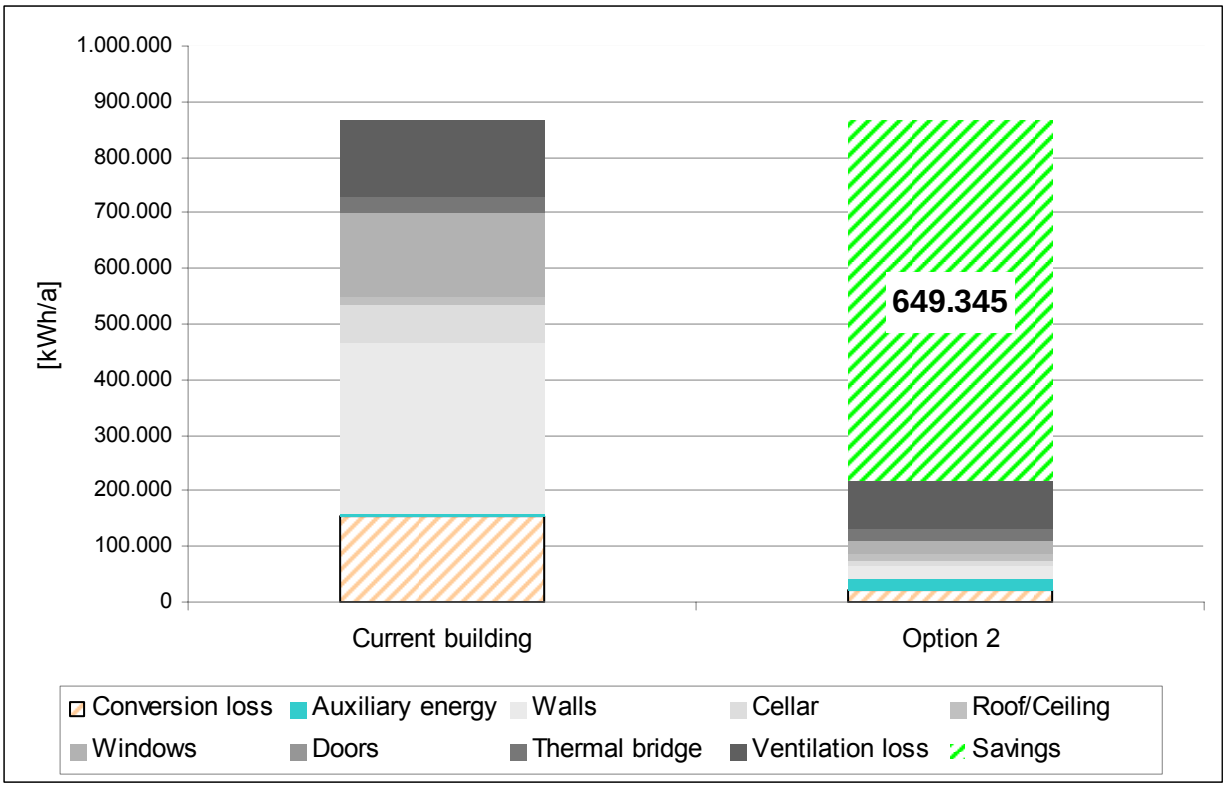
Annual demand for primary energy




Transmission heat loss

### *Measures:*

- Insulation exterior wall (14 cm, thermal insulation composite system 035)
- Replacement Windows (Thermal transmission coefficient = 1,1 [W/(m²K)] )
- Replacement entrance doors (Thermal transmission coefficient = 2,0 [W/(m²K)] )
- Replacement heat generator (district heating, combined heat and power, fossil fuel)
- Installation solar domestic hot water with a bivalent cistern
- Installation decentralized exhaust-air plant with heat recovery and air density validation
- Replacement thermostatic valve (design range 1 kelvin)
- Insulation basement (4 cm, thermal insulation composite system 025)

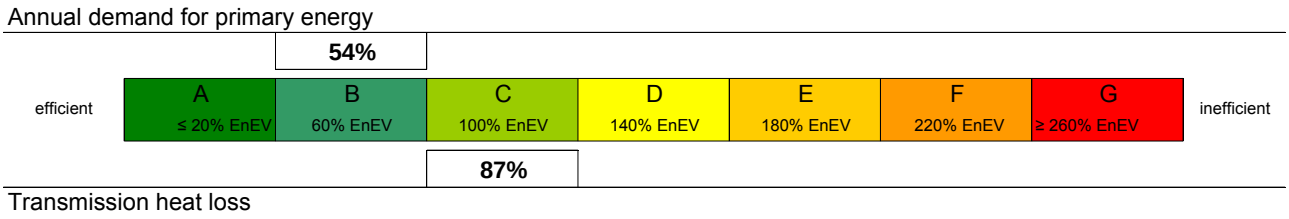



### *Financing:*

- Support program: KfW - Energy-Efficient Rehabilitation, *Efficiency House 100*
- Conditions: low interest financing incl. subsidy in the amount of 12,5%

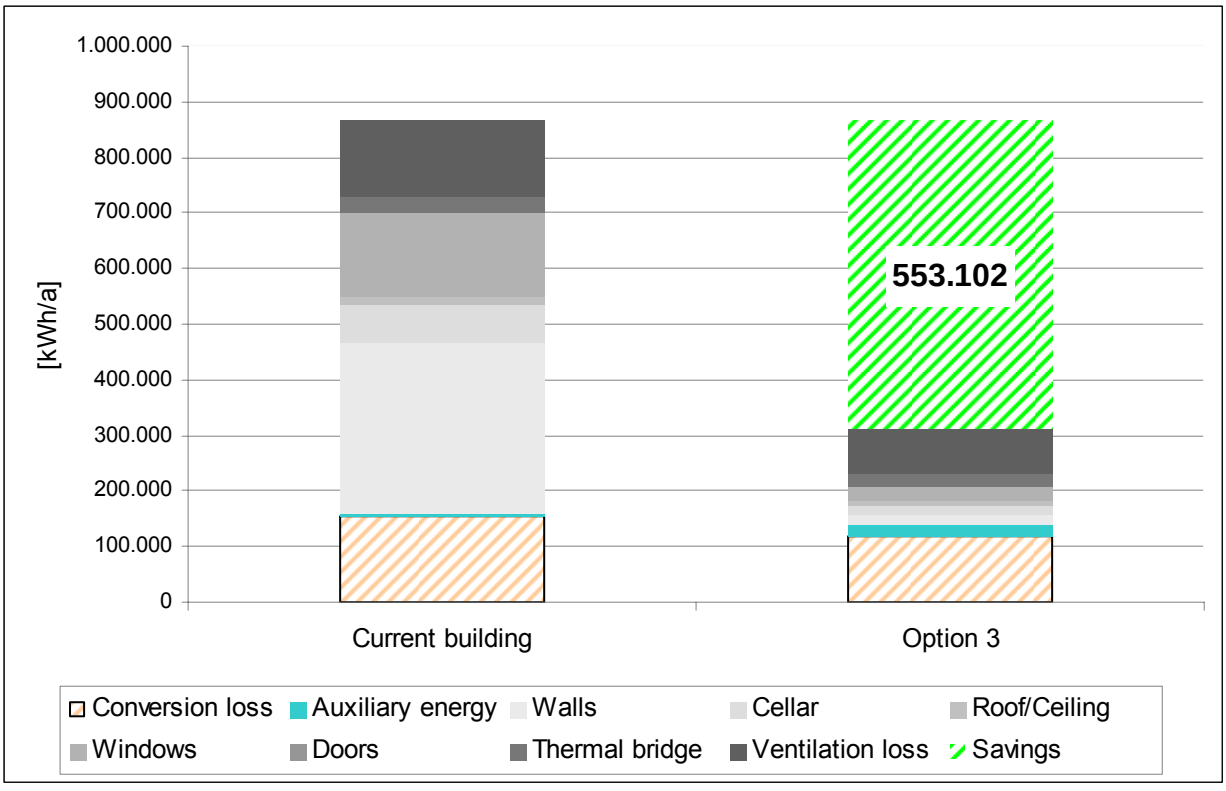
## Option 3: KfW 85

Classification of the energetic quality is based on the target values of EnEV 2009.




### *Measures:*

- Insulation exterior wall (14 cm, thermal insulation composite system 035)
- Replacement Windows (Thermal transmission coefficient = 1,1 [W/(m²K)] )
- Replacement entrance doors (Thermal transmission coefficient = 2,0 [W/(m²K)] )
- New heat generator (wood pellets)
- Installation solar domestic hot water with a bivalent cistern
- Installation decentralized exhaust-air plant with heat recovery and air density validation
- Replacement thermostatic valve (design range 1 kelvin)
- Insulation basement (4 cm, thermal insulation composite system 025)




### *Financing:*

- Support program: KfW - Energy-Efficient Rehabilitation, *Efficiency House 85*
- Conditions: low interest financing incl. subsidy in the amount of 15%

# Overview options

## Energy-saving measures

| Construction component | Option 1 | Option 2 | Option 3 |
|---|---|---|---|
| *KfW program*<br>*Subsidy* | Efficiency House 115<br>7,5% | Efficiency House 100<br>12,5% | Efficiency House 85<br>15% |
| | | | |
| Exterior wall | 14 cm (035) | Same as Option 1 | Same as Option 1 |
| Entrance doors | 2,0 [W/(m²K)] | Same as Option 1 | Same as Option 1 |
| Windows | 1,1 [W/(m²K)] | Same as Option 1 | Same as Option 1 |
| Basement | - | 4 cm (025) | Same as Option 2 |
| Thermostatic valve | Design range 1 kelvin | Same as Option 1 | Same as Option 1 |
| Air density validation | Yes | Yes | Yes |
| Thermal bridge validation | No | No | No |
| Heat Generator | District heating (combined heat and power) | Same as Option 1 | Wood pellets |
| Solar support for | Domestic hot water | Same as Option 1 | Same as Option 1 |
| Ventilation | Decentralized exhaust-air plant with heat recovery | Same as Option 1 | Same as Option 1 |

## Energetic results of options

| | | Current building | Option 1: KfW 115 | Option 2: KfW 100 | Option 3: KfW 85 |
|---|---|---|---|---|---|
| **Qp** concerning target value EnEV | < KfW xy in % | 557,57 | 114,20 | 92,77 | 53,54 |
| **H'T** concerning reference building | < KfW (xy+15) in % | 498,60 | 154,30 | 109,20 | 109,20 |
| **H'T** concerning target value EnEV | < 140 % | 399,30 | 123,50 | 87,40 | 87,40 |
| **Qp** (according to EnEV) | [kWh/(m²a)] | 250,20 | 51,20 | 41,60 | 24,00 |
| **H'T** (according to EnEV) | [W/(m²K)] | 1,996 | 0,618 | 0,437 | 0,437 |
| **H'T** (permissible according to EnEV) | [W/(m²K)] | 0,500 | 0,500 | 0,500 | 0,500 |
| **H'T** (reference building) | [W/(m²K)] | 0,400 | 0,400 | 0,400 | 0,400 |
| Specific demand for **heating energy** | [kWh/(m²a)] | 146,60 | 45,50 | 32,30 | 32,30 |
| Specific demand for **final energy** | [kWh/(m²a)] | 191,20 | 61,40 | 48,00 | 69,20 |
| Norm heating load according to DIN 4108-6 | [kW] | 518,80 | 212,90 | 172,80 | 172,80 |

## Building costs

The costs of additional measures are estimated and are stated as pre-tax costs. They need to be checked by a conducting planning office.

## Overview building costs in €

**Buildings costs:**

| | Option 1 | Option 1 | Option 2 | Option 2 | Option 3 | Option 3 |
|---|---|---|---|---|---|---|
| Housing units: | 60 | | 60 | | 60 | |
| Floor size [m²] : | 5.239 | per m² | 5.239 | per m² | 5.239 | per m² |
| Building site equipment | 2.544 € | - | 2.544 € | - | 2.544 € | - |
| Roof | 0 € | 0 € | 0 € | 0 € | 0 € | 0 € |
| Exterior walls | 392.900 € | 181 € | 392.900 € | 181 € | 392.900 € | 181 € |
| Windows | 219.900 € | 448 € | 219.900 € | 448 € | 219.900 € | 448 € |
| Staiway walls | 0 € | 0 € | 0 € | 0 € | 0 € | 0 € |
| Cellar | 0 € | 0 € | 42.000 € | 40 € | 42.000 € | 40 € |
| Installation engineering | 216.900 € | - | 216.900 € | - | 248.200 € | - |
| *Net building costs* | *832.244 €* | | *874.244 €* | | *905.544 €* | |
| Air density validation | 30.000 € | | 30.000 € | | 30.000 € | |
| Thermal bridge validation | 0 € | | 0 € | | 0 € | |
| Additional building costs* 15% | 128.474 € | | 134.732 € | | 139.396 € | |
| *(incl. planning costs, commencement work at building site, …) | | | | | | |
| **All-in cost of building** | **990.719 €** | | **1.038.977 €** | | **1.074.940 €** | |
| *corresponds to per m² floor size* | *189 €* | | *198 €* | | *205 €* | |

| **Fictional support*** *(for building being in Germany) | **Option 1** | | **Option 2** | | **Option 3** | |
|---|---|---|---|---|---|---|
| KfW - program: | KfW 115 | | KfW 100 | | KfW 85 | |
| Subsidy: | | | | | | |
| 7,5% | 74.304 € | | | | | |
| 12,5% | | | 129.872 € | | | |
| 15,0% | | | | | 161.241 € | |
| **All-in cost of building <u>past</u> subsidy:** | **<u>916.415 €</u>** | | **<u>909.105 €</u>** | | **<u>913.699 €</u>** | |
| *corresponds to per m² floor size* | *<u>175 €</u>* | | *<u>174 €</u>* | | *<u>174 €</u>* | |

## Overview building costs in BYR

The exchange rate is set to 4.000 BYR/€ and in addition the German costs are reduced by the factor of 0,7 to fit the Belarusian costs.

**Buildings costs:**

| | Option 1 | Option 1 | Option 2 | Option 2 | Option 3 | Option 3 |
|---|---|---|---|---|---|---|
| Housing units: | 60 | | 60 | | 60 | |
| Floor size [m²] : | 5.239 | per m² | 5.239 | per m² | 5.239 | per m² |
| Building site equipment | 7,12 Mio. BYR | - | 7,12 Mio. BYR | - | 7,12 Mio. BYR | - |
| Roof | 0 Mio. BYR | 0 Mio. BYR | 0 Mio. BYR | 0 Mio. BYR | 0 Mio. BYR | 0 Mio. BYR |
| Exterior walls | 1.100,12 Mio. BYR | 0,506 Mio. BYR | 1.100,12 Mio. BYR | 0,506 Mio. BYR | 1.100,12 Mio. BYR | 0,506 Mio. BYR |
| Windows | 615,72 Mio. BYR | 1,255 Mio. BYR | 615,72 Mio. BYR | 1,255 Mio. BYR | 615,72 Mio. BYR | 1,255 Mio. BYR |
| Staiway walls | 0 Mio. BYR | 0 Mio. BYR | 0 Mio. BYR | 0 Mio. BYR | 0 Mio. BYR | 0 Mio. BYR |
| Cellar | 0 Mio. BYR | 0 Mio. BYR | 117,60 Mio. BYR | 0,112 Mio. BYR | 117,60 Mio. BYR | 0,112 Mio. BYR |
| Installation engineering | 607,32 Mio. BYR | - | 607,32 Mio. BYR | - | 694,96 Mio. BYR | - |
| *Net building costs* | *2.330 Mio. BYR* | | *2.448 Mio. BYR* | | *2.536 Mio. BYR* | |
| Air density validation | 84,00 Mio. BYR | | 84,00 Mio. BYR | | 84,00 Mio. BYR | |
| Thermal bridge validation | 0 Mio. BYR | | 0 Mio. BYR | | 0 Mio. BYR | |
| Additional building costs* 15% | 360 Mio. BYR | | 377 Mio. BYR | | 390 Mio. BYR | |
| *(incl. planning costs, commencement work at building site, …) | | | | | | |
| **All-in cost of building** | **2.774 Mio. BYR** | | **2.909 Mio. BYR** | | **3.010 Mio. BYR** | |
| *corresponds to per m² floor size* | *0,530 Mio. BYR* | | *0,555 Mio. BYR* | | *0,575 Mio. BYR* | |
| **Fictional support*** *(for building being in Germany) | **Option 1** | | **Option 2** | | **Option 3** | |
| KfW - program: | KfW 115 | | KfW 100 | | KfW 85 | |
| Subsidy: 7,5% | 208 Mio. BYR | | | | | |
| 12,5% | | | 364 Mio. BYR | | | |
| 15,0% | | | | | 451 Mio. BYR | |
| **All-in cost of building <u>past</u> subsidy:** | **<u>2.566 Mio. BYR</u>** | | **<u>2.545 Mio. BYR</u>** | | **<u>2.558 Mio. BYR</u>** | |
| *corresponds to per m² floor size* | *<u>0,490 Mio. BYR</u>* | | *<u>0,486 Mio. BYR</u>* | | *<u>0,488 Mio. BYR</u>* | |

## Description of assessed building costs

### Costs of installation engineering in €

| Housing units: | 60 | 60 | 60 |
|---|---|---|---|
| Floor size: | 5.239 | 5.239 | 5.239 |
| Floor size per housing unit: | 87,3 | 87,3 | 87,3 |
| | **Option 1** | **Option 2** | **Option 3** |
| **Installation engineering** | | | |
| **Heating** | 34.374 € | 34.374 € | 65.714 € |
| System | District heating (combined heat and power) | District heating (combined heat and power) | Wood pellets |
| Costs new heat generator | 0 € | 0 € | 31.340 € |
| Solar support | 0 € | 0 € | 0 € |
| Distribution system | 0 € | 0 € | 0 € |
| Hydraulic adjustment | 23.574 € | 23.574 € | 23.574 € |
| New valves | 10.800 € | 10.800 € | 10.800 € |
| **Domestic hot water** | 96.064 € | 96.064 € | 96.064 € |
| System | via heating | via heating | via heating |
| Distribution system | 0 € | 0 € | 0 € |
| Hydraulic adjustment | 18.336 € | 18.336 € | 18.336 € |
| Solar support | 67.077 € | 67.077 € | 67.077 € |
| New cistern | 10.652 € | 10.652 € | 10.652 € |
| **Ventilation** | | | |
| System | heat recovery | heat recovery | heat recovery |
| Exhaust-air plant | 86.439 € | 86.439 € | 86.439 € |
| Per housing unit | 1.441 € | 1.441 € | 1.441 € |
| | 216.878 € | 216.878 € | 248.218 € |
| **All-in installation engineering** | **216.900 €** | **216.900 €** | **248.200 €** |

## Costs of installation engineering in BYR

The exchange rate is set to 4.000 BYR/€ and in addition the German costs are reduced by the factor of 0,7 to fit the Belarusian costs.

| Housing units: | **60** | **60** | **60** |
|---|---|---|---|
| Floor size: | 5.239 | 5.239 | 5.239 |
| Floor size per housing unit: | 87,3 | 87,3 | 87,3 |
| | **Option 1** | **Option 2** | **Option 3** |
| **Installation engineering** | | | |
| **Heating** | 96,25 Mio. BYR | 96,25 Mio. BYR | 184,00 Mio. BYR |
| System | District heating (combined heat and power) | District heating (combined heat and power) | Wood pellets |
| Costs new heat generator | 0 Mio. BYR | 0 Mio. BYR | 87,75 Mio. BYR |
| Solar support | 0 Mio. BYR | 0 Mio. BYR | 0 Mio. BYR |
| Distribution system | 0 Mio. BYR | 0 Mio. BYR | 0 Mio. BYR |
| Hydraulic adjustment | 66,01 Mio. BYR | 66,01 Mio. BYR | 66,01 Mio. BYR |
| New valves | 30,24 Mio. BYR | 30,24 Mio. BYR | 30,24 Mio. BYR |
| **Domestic hot water** | 268,98 Mio. BYR | 268,98 Mio. BYR | 268,98 Mio. BYR |
| System | via heating | via heating | via heating |
| Distribution system | 0 Mio. BYR | 0 Mio. BYR | 0 Mio. BYR |
| Hydraulic adjustment | 51,34 Mio. BYR | 51,34 Mio. BYR | 51,34 Mio. BYR |
| Solar support | 187,82 Mio. BYR | 187,82 Mio. BYR | 187,82 Mio. BYR |
| New cistern | 29,82 Mio. BYR | 29,82 Mio. BYR | 29,82 Mio. BYR |
| **Ventilation** | | | |
| System | heat recovery | heat recovery | heat recovery |
| Exhaust-air plant | 242,03 Mio. BYR | 242,03 Mio. BYR | 242,03 Mio. BYR |
| Per housing unit | 4,03 Mio. BYR | 4,03 Mio. BYR | 4,03 Mio. BYR |
| | 607,26 Mio. BYR | 607,26 Mio. BYR | 695,01 Mio. BYR |
| **All-in installation engineering** | **607 Mio. BYR** | **607 Mio. BYR** | **695 Mio. BYR** |

# Appendix 1 - Glossary / Questions

## Primary energy

The energy contained in a fuel before it is processed. It has not been subjected to any conversion or transformation process.

## Final energy

Energy fuels used by final consumers (e.g. households); typically modern final energy forms and fuels are generated involving various steps of conversion from primary energy to final energy.

## Why is option 3 rated better than option 2 with option 3 having a higher conversion loss and less savings than option 2?

The energy-saving measures on both options are the same. They have an equal demand for final energy. The answer for this question is found in the heat generation. The demand for primary energy of option 2 is higher than the one of option 3. District heating is rated worse than wood pellets. District heating is often made of fossil fuels which have to be transported over long distances. Wood pellets are more likely to be produced in a local area and are accounted as renewable energy.

So the answer for the question is the focus of the EnEV on the primary energy and not the final energy. The whole process of energy generation, distribution and consumption is observed.