Energy efficient residential buildings in Belarus

Analysis and recommendation

Energy efficient residential buildings in Belarus

Analysis and recommendation

Matthias Grätz, Heidrun Fammler, Martin Krekeler (Baltic Environmental Forum Deutschland)

Christiane von Knorre, Rose Scharnowski, Liana Stoica (Auraplan)

Michael Anufriev, Alina Bushmovich (Ecopartnership)

Baltic Environmental Forum, Hamburg, 2016

Layout: Matthias Grätz

Cover picture: Rose Scharnowski

This report has been compiled in the project „Evaluation of energy performance of pilot buildings in Belarus„ (EnPeBel) which took place within the GIZ program "Capacity Development for Climate Policy in the Western Balkan, Central and Eastern Europe and Central Asia". The goal of the project EnPeBel is to improve the quality of construction in refurbishment and new appartment buildings in Belarus. EnPeBel was a joint project of the Baltic Environmental Forum Germany and Ecopartnership, Belarus. The team was supported by the architecture office Auraplan. EnPeBel was part of the International Climate Initiative (IKI). The German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) supports this initiative on the basis of a decision adopted by the German Bundestag.

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

On behalf of:

Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety

of the Federal Republic of Germany

Table of Contents

Summary

This report provides an analysis of the energy efficiency in new residential buildings in Belarus which have been designated to fulfil a higher than average energy standard. The energy demand of these buildings was found not to match initial calculations. We re-calculated the energy demand of these buildings based on more realistic assumptions, and inspected the building quality by site visits and interviews with the flat owners. The report shows that the reasons for a higher energy consumption are manifold, starting from too optimistic assumptions for certain parameters such as the indoor temperature, not exact installation of windows, use of outdated technology, ventilation and heating behaviour of residents contributing to energy losses. Furthermore, quality control which could detect construction mistakes early on is insufficient. On a positive note, we do also find that overall construction quality has generally increased over the past years. This report finishes with a set of recommendations addressing construction questions and systemic issues.

Borodina St. 18, Gomel'. Picture: M. Anufriev

Introduction

The demand for new residential buildings is very high in Belarus in the aftermath of Soviet Rule which was characterised by a very limited amount of m^2 of living space per person. Consequently a lot of new multi-storey apartments are constructed each year in Belarus and the housing and construction sector plays an important role in the country's economy. However, the residential sector in Belarus accounts for approximately one quarter of the country's electricity consumption and more than 40% of the heat consumption. The efficient use of energy is among the most important long-term objectives of the state and the government has set ambitious goals and adopted respective legislation under its "Comprehensive Programme for the Design, Construction and Reconstruction of Energy-Efficient Houses in the Republic of Belarus for 2009-2010 and until 2020". One of the objectives is that many of the newly constructed houses built after 2014 must be energy efficient. Reaching the goals of the housing programme under current conditions - housing and energy sector are monopolised by the state, construction is based on standardised processes that hinder effective cooperation and quality control, and, the end-user (inhabitant) lack awareness and motivation to act - is difficult and needs support, also from foreign experts and projects. In particular, it has been noted by the Belarusian Ministry of Housing and Communal Services that the real energy performance of newly constructed and refurbished buildings does not meet the calculated standards. In this paper we analyse the current situation of energy efficiency in residential buildings – based on the detailed analysis of selected houses – and point out reasons why the calculated energy demand mismatches the actual consumption.

Analysis of houses

Background

The responsibilities for energy efficiency in buildings in Belarus are shared between two ministries: The Ministry for Housing and Communal Services is in charge of energy supply to residential buildings while the design of buildings including initial calculations on the energy demand of residential buildings is in the responsibility of the Ministry of Architecture and Construction. The Ministry of Architecture and Construction has commissioned the construction of approximately 20 new residential buildings that were designed to be more energy-efficient than average new constructions. These buildings are located in the regions of Minsk, Gomel, Brest, Mogilev and Vitebsk and were built between 2007 and 2013. The Ministry of Housing and Communal Services is monitoring the energy efficiency of these houses and found out that many of them have different technical problems which were noticed by the inhabitants, the house owner associations and the maintenance companies in charge of energy supply and metering. As a result a significant mismatch between the calculated energy demand and the actual consumption was identified.

Explaining this gap has been motivation and the starting point for the project. Based on the 19 buildings that were indicated as potential case study objects, the project team selected a number of houses for further investigation, based on a number of criteria. First of all, it was checked whether a complete set of documents for the building in question was available. The scope of the documentation, coverage of details and "up-to-dateness" of the documentation have been taken into consideration, too. The selection of buildings should include residential houses in other cities than Minsk and should cover refurbished and new buildings. The selected new buildings should cover different years of construction to take into account a possible change in the way the houses are constructed. Last but not least, the readiness of the home owner associations of the buildings to contribute to the project and work with the project's experts will be a criterion for decision. The selection process lead to 5 houses that were further investigated by the project:

1. Kazimirovskaya St. 17, Minsk
2. Kalinovskogo St. 64, Minsk
3. Youth housing cooperative "Solnechniy", 6th housing, Gomel
4. Borodina St. 18, Gomel
5. 1st Khasanovskaya St. 62, Lida

Assessment procedure

The assessment procedure followed the same number of steps in all of the five selected buildings. At first, the documentation of the buildings was collected. Next, the buildings were digitalised and their heat energy demand was calculated with the help of the phpp software package. The calculation of the heat energy demand was based on different assumptions:

- Interior temperature 20°C,
- Average occupancy following the recommended standard value of the Passive House Institute leading to interior heat gains of 2,11 W/m²,
- Average air exchange rate through infiltration.

It could not always be established to which of the areas the officially indicated heat energy demand referred. The different assumptions lead to different calculation results. We will indicate a range of the heat energy demand that reflects the range of assumptions.

In a next step, the building was visited and expected by the project's experts. During the site visits, surface and inner temperatures were measured in flats. The access to flats was up to the owners of the flats, so that the measurements are not fully systematic, such as a selection of flats with outside walls, on the top floor or ground floor. In most buildings, however, several flats could be visited, so that it is possible to draw conclusions.

In addition to the measurements, a survey was carried out among the inhabitants of four of the buildings. With the help of the survey, additional aspects of the building quality and subjective indoor comfort could be inquired in two buildings where we had a sufficient return rate.

Description of the selected buildings

1 – Residential building in Kazimirovskaya St. 17, Minsk

Description of the building

The building in Kazimirovskaya St. 17, located in the west of Minsk is a new 16-storey residential building, built in 2011. This apartment building has 126 flats on a total heated area of 8.688 m². It is the largest building of those analysed in this project. The building is compact and has a favourable surface to volume ratio of 0,3. The local planners indicated a heat demand of 39,5 kWh/m²a for the entire building. The re-calculated energy demand ranges from 43 kWh/m²a for a flat in the middle up to 83 kWh/m²a for the shared space – the entire building is calculated with 56 kWh/m²a. The increased values, compared to the heat demand given by the local planner might be due to the increased indoor temperatures of approx. 23°C (measurement and survey) compared to the assumed 20°C.

Inspection of the building

The inspection of the building found a few critical points on the outside of the building, in particular not properly installed windows, missing or damaged sealing and sealing foam which is not properly covered. Flats are equipped with a mechanical ventilation system which includes a heat exchanger in the 16th floor. Supply air is provided in the living rooms while the exhaust air vents are located in kitchens and bathrooms. 64% of the interviewed residents do not use other ventilation systems than the one installed, other use fans or classical ventilation through windows and doors to improve air ventilation and circulation. Radiators are equipped with thermostat valves so that the indoor temperature can be regulated by the flat owners. Thermographic measurements at walls and windows indicate big temperature differences between surface and indoor air. On average, this difference was higher at windows and in some cases the window frame temperature is below the dew point temperature, which indicates that the quality of window installation is not satisfactory. This varies from room to room, however, so that systematic errors can be excluded, such as a poor quality of windows. The result is supported by the survey results where 24% of the respondents claim that the windows are not installed properly; approx. 18% say that they have defects in their window sills and 9% say that they have mould near the windows.

Conclusions & recommendations

The energy consumption is higher than preliminary expected. The indoor temperature is higher than calculated. The heating system has the capacity to provide higher indoor temperatures. The quality of installation of windows differs from room to room. This causes additional energy losses and in some cases problems with mould have been found near the windows. According to the metering results in the common spaces, the insulation between heated and unheated areas is insufficient.

Careful repair of gaps between window frame and wall, if possible new airtight sealing from inside and outside. Installation of insulation between heated and unheated common spaces according to fire protection requirements.

Kazimirovskaya 17. Picture: R. Scharnowski

2 – Residential building in 1st Khasanovskaya St. 62, Lida

Description of the building

The building in Lida is a smaller residential building, which was erected in 2000. The evaluated house has just six flats on four storeys. The heated area is 1.432 m² and the thermal envelope is 2.650 m². Due to the complicated architecture of the building, the surface to volume ratio has an unfavourable value of 0,74. Resulting from the complicated architecture and the resulting heat losses, the building has a final heat demand was calculated with 123 kWh/m²a. Thermal bridges contribute 19 kWh/m²a to the total heat losses, while windows and external walls 66 kWh/m²a. These represent 46% of the total heat loss, followed by ventilation loss representing 29% of the total losses. Additionally, losses due thermal bridges and windows and external walls represent 66% of the total transmission losses.

Inspection of the building

During the inspection of the building at place, humidity damages, cracks, and damages at plaster were detected on the outside of the building. Especially, the complex profile of the roof edge generated problems with the water drainage. Despite the relative young age of the building, the flats offer no regulation by valves at the thermostats. The rooms are equipped with old fashioned types of heaters. However, the pipes are well insulated in non-heated areas of the building.

The metering results on the walls and ceilings that were undertaken during the site visit, confirmed the existence of thermal bridges. Especially at the windows, the temperature difference between surface and room temperature is significant.

The metering results in the attic show an indoor temperature of up to 22°C. As long as these rooms are not used as living area, it is recommended to define them as unheated and to insulate the floor of the attic storey temporarily. In that way, the heat consumption of the building could be reduced.

Conclusions & recommendations

The site visits and evaluations lead to the finding that the energy consumption is higher than preliminary expected. The inner temperature is higher than calculated, too. The heating system has the capacity to provide higher inner temperatures. The complex shape of facades and the roof result in a high building shape factor (A/V ratio 0,74) as well as the occurrence of thermal bridging. The metering results on wall and ceiling confirm this problem.

In mid-term, it is recommended to repair the rain drainage system to avoid further damage. The insulation of the ceiling to the unheated attic storey should be considered. Last but not least, thermostat valves should be installed at all radiators inside the flats.

1st Khasanovskaya St. 62, Lida. Picture: R. Scharnowski

3 – Residential building in Kalinovskogo St. 64, Minsk

Description of the building

The building in Kalinovskogo St. 64 is an older building which was refurbished in 2011. With 48 flats on 5 storeys it is a rather small building in Minsk. The heated area is 3.055 m² and the thermal envelope is 3.905 m². The surface to volume ratio of the building is 0,5. The final heat demand of the building was calculated with 104 kWh/m²a if the external walls to the balconies are not insulated or 98 kWh/m²a if they are insulated. During the insulation, the windows were not exchanged. The exchange of windows was in the responsibility of each flat owner.

Inspection of the building

In general, the building is well-maintained, especially the roof covering. The inspection of the building showed that only a small number of flat owners actually did replace their windows before the building was insulated. Installation of new windows after refurbishment would cause problems with the installed thermal insulation system. Furthermore, the balconies were not upgraded or even altered. The initial single pipe wall heating system was not replaced during the refurbishment. Thus, it is still not possible to regulate the temperature inside the flats. For most flats, the insulation of the outer wall remains the only measure during the refurbishment process which has an influence on the heat consumption. The flats that were visited were located in the middle of the single pipe-circulation line. In those flats, the windows were kept open to keep the temperature around 19°C. However, the low surface temperatures of the old-fashioned window frames leads to the fact that in some cases, even the dew point was met. This problem does not occur on the walls thanks to the wall heating system.

Conclusions & recommendations

As the former single pipe wall heating system was not changed, it is still impossible to regulate the temperature inside the flats. Consequently, the energy consumption is not influenced by the inhabitants' behaviour. Any exchange of the old windows (to avoid energy losses and dew points) should only be done taking into account the requirements of the insulation. A more comprehensive refurbishment of the building would require the exchange of the heating system of the whole building, the installation of heaters and thermostat valves. This would, however, demand a complex solution as the current heating system cannot be exchanged easily and would probably require the installation of a completely new system additionally while shutting down the existing heating system.

Kalinovskogo St. 64. Picture: R. Scharnowski

4 – Residential building in Borodina St. 18, Gomel’

Description of the building

The apartment building in Borodina St. 18 in Gomel’ is a 9-storey high-rise with 108 flats, built in 2012. The heated areas of the building is 5.733 m² while the thermal envelope is 7.638 m². The surface to volume ratio is 0,5. According to survey and metering results, we can assume that the average indoor temperature is around 23,5° which would lead to a calculated energy demand of 95 kWh/m²a, or 102 kWh/m²a if we assume increased thermal bridges at the windows.

Inspection of the building

The inspection of the building led to few findings on the outside of the building. Apart from some not properly installed window sills, no critical points were identified. Inspecting some apartments from the inside showed that some radiators cannot be regulated by valves and that heater models are rather old-fashioned. The flats are not equipped with a ventilation system, despite the fact that this is the youngest building analysed in the project. Thermographic measurements at windows reveal significant thermal bridges. A significant difference of more than 6,5°C between the metered surface and indoor temperature indicates the critical condition in which thermal bridges are forming. These seems caused by a deficient installation of the windows whereby no systematic error could be detected.

Conclusions & recommendations

The energy consumption is higher than preliminary expected. The indoor temperature is higher than calculated. The heating system has the capacity to provide higher indoor temperatures. The quality of installation of windows differs from room to room. This causes additional energy losses. In some flats there are no thermostat valves.

The exchange of old fashioned valves according the balance of the whole heating system is needed eventually. In some cases the reorganization of covered heaters to improve their efficiency should. Careful repair of gaps between window frame and wall, if possible new airtight sealing from inside and outside. A repair of damaged plaster is recommended to avoid more damages.

Borodina St. 18, Gomel‘. Picture: R. Scharnowski

5 – Residential building Solnechniy, Gomel’

Description of the building

The building in Solnechniy was built in 2005 and offers 36 flats on 9 storeys. The heated area is 3.789 m² and the thermal envelope is 4.037m². The surface to volume ratio is 0,4 which is a rather favourable value and indicates a compact building. The calculated heat demand by the planner has been given with 19,8 kWh/m²a which is in stark contrast to the values re-calculated by the project experts. The re-calculated values range from 54 kWh/m²a for an apartment in the middle of the building with an orientation to the South up to 90 kWh/m²a if we consider the entire building and assume that the staircase is outside the heated volume.

Inspection of the building

The outside of the building shows some damage on plaster and walls. This was also confirmed in the residents’ survey, where 24% of the respondents confirm to have cracks in the walls. Furthermore, some parts of the plaster were humid on the outside and some of the windows were not properly sealed or installed. Regarding the interior of the building, the heaters inside the flats are equipped with thermostatic valves, so that the temperature can be regulated inside the flats. However, the windows emerge as a problem: a significant difference (6,5°C) between the metered surface and indoor temperature indicate the critical conditions in which thermal bridges form. This measurement is also supported by the survey among residents in which 22% of the respondents confirm the formation of mould near the windows. This is caused by a deficient installation of the windows: 16% of the interviewed residents say that their windows are not installed properly and 10% noticed defects at the window sills. However, similar to the building in Borodina St, the quality of window installation differs from room to room, there are no systematic construction mistakes.

Conclusions

The energy consumption is higher than preliminary expected. The indoor temperature is higher than calculated (survey and metering results suggest an average temperature of around 22°C). The heating system has the capacity to provide higher inner temperatures. The quality of installation of windows differs from room to room. This causes additional energy losses and in some cases leads to problems with mould near the windows.

The repair of seal at the window wing, a careful repair of gaps between the window frame and wall, and if possible new airtight sealing from inside and outside would be necessary.

Solnechniy, Gomel‘.
Picture: R. Scharnowski

Results from the inspections and building analysis

All five surveyed buildings show a discrepancy between promised or planned low final energy consumption before construction and assumed realistic consumption data which are based on calculations and observations. There are a number of reasons for that:

- The rooms are heated up to higher temperatures as assumed in the calculation.
- The quality of construction material has increased, for example windows are triple-glazed. However, the quality of instruction varies and higher heat losses are caused by leaky windows compared to the calculations.
- In addition to the afore-listed problems, there are a number of individual problems, e.g. missing insulation between heated and unheated stair cases, partially selection of old construction parts such as heating valves.

In conclusion, none of the buildings reaches the promised good energy standards. In comparison to the building stock in Belarus, they are however better than most other buildings in Belarus, in terms of the energy standard. The buildings that have been analysed do show a trend that the quality of planning and the attention paid to details has generally increased over time, e.g. we observe more carefully installed insulation in unheated rooms or a better choice of materials or technology (ventilation systems).

The geographic location of the analysed buildings did not have an influence on construction quality or thermal performance, neither positively nor negatively.

Systematic findings and conclusions

The findings and conclusions can be structured along the different phases of the building. We present some systematic findings in construction chronologic order below, starting from the planning phase up to the operational phase.

1 – Planning phase

During the planning phase, the following main findings can be identified: First of all, the calculation assumptions for the residential buildings do not reflect the real conditions in which the residential buildings are used later on. In particular, the assumed indoor temperature and the assumptions regarding the occupancy seem to be too optimistic. The indoor temperature is assumed with 18°C in calculations for the building permit, however the indoor temperature is rarely that low and usually ranges between 22 and 25°C according to our measurements and the information provided by the inhabitants. This increases the heating demand significantly, we estimate that this creates an additional demand for heat energy of 25%. The re-calculation of the energy consumption in the buildings were done on an assumption of 20°C (this figure is e.g. recommended by the software used for re-calculation), in comparison to the 18°C used in the initial calculation in the planning phase of the building. Even our assumption was conservative, so that it is highly likely that our re-calculations were also too low regarding the energy demand.

In contrast, the occupancy that we assumed for the buildings was too pessimistic – we calculated that there would be 35 m^2/person which would need to be reduced to 25-30 m^2/person, thus leading to higher internal gains. These additional gains are however comparatively small, so that the real energy consumption is very likely still higher, taken both the increase internal gains and higher indoor temperatures into account.

2 – Construction phase

During the construction phase, the major problem is insufficient quality of the installation of construction parts, such as windows. Especially with regard to windows, imprecise installation of the window will lead to thermal bridges and draughts. We ascribe such mistakes primarily to the insufficient qualification of the workers at the construction site to pay attention to such details. However, also the supervision during the construction and also the acceptance of work does not put sufficient emphasis on correcting such construction mistakes later on. In conclusion, we notice that the general quality control is insufficient.

The mistakes made during the construction are seldom a case for liability claims. Relevant rules and liability legislation exists, however it is usually cheaper for citizens to repair construction mistakes on their own and live in their apartments rather than to demand the correction of the defects by the developer or to request compensation for costs incurred. The reasons are insufficient awareness of their rights, missing possibilities to make proper claims, or high associated costs with law cases which the client has to face upfront. The burden of proof that the mistake has been made during the construction phase is often on the owner of the new flat which usually does not have sufficient expertise to substantiate his claim. Apartments in apartment blocks are constructed according to standard designs with equally approved layouts, placement of plumbing, electrical equipment etc. Residents who participate in shared housing construction and pay for the construction, knowing that they will actually have to do major repairs (re-planning and modifications such as the replacement of doors, window frames, electrical wiring, plumbing etc.). In such cases, a flat owner is not entitled to claim the correction of identified defects from the developer.

Consequently, all these reason lead to the situation that it is more cost-effective for a flat-owner, even if he is aware of his rights and of ways to claim those, not to seek restoration of his right, but to correct construction mistakes on his own.

3 – Building in use

The way the buildings are used has an influence on the energy consumption. What was especially noteworthy and has been mentioned already, are the high indoor temperatures, often 23°C and more. This is regardless of the possibility to regulate the radiators in the flats or not. We conclude, that a higher indoor temperature is generally associated with a more comfortable interior climate in Belarus.

Apart from the higher indoor temperature, we observed during the visits of the flats that rooms where ventilated with open windows, while the heating was switched on. This will lead to additional heat losses. It can be assumed that this is still ingrained behaviour from earlier times when radiators could not be regulated and the room temperature was adjusted by opening and closing the windows. The results from the residents' survey suggest furthermore that temperatures are not reduced when leaving the home by turning down the setting of the radiators.

Another noteworthy fact is the use of balconies. Balconies are used for different purposes; in many cases they are used as an extension of the living room or are used as dining room. This can have an impact on the energy performance if no additional insulation measures are undertaken and the doors or windows between balcony and flat interior are kept open for longer time periods.

4 – Documentation and certification

Another problem which appears to be systematic is the documentation of buildings. Although this is not necessarily a specific problem for Belarus, we noted that it was difficult to obtain sufficient documentation about a building to prepare new calculations on the energy consumption.

Energy performance certificates (EPCs) are not yet available for residents or flat owners. The only point when the energy performance of the building is indicated is during the building permit stage where the calculated energy demand is given in the documents to be handed-in. There have been projects, e.g. by the UNDP that give recommendations on EPCs and certification. Indeed, according to current plans an energy performance certificate will be obligatory soon - not only during the design stage but also after energy audit of existing building. However, there are still questions whether this document will be actually available to tenants. Furthermore, EPCs will only be issued for newly constructed buildings and those, which undergo an energy audit. In total, this is still a very limited number of buildings.

Apart from the missing energy performance certificate and final quality check, the energy consumption is also not monitored in a more detailed fashion although the houses which have been in the focus of the project have been part of a group of especially energy efficient residential houses. There has been no systematic accompanying study or series of measurements during the first heating period that tested the validity of the assumptions on which the calculation of the energy consumption has been based.

Conclusions and recommendations

The analysis of the buildings and the situation regarding energy efficiency in the residential building sector did not lead to the identification of one main reason, but rather to a list of reasons that all contribute to reduced energy efficiency in comparison to the planned high efficiency standard. In general we notice that the described problems often lead back to a similar pattern: a lack of verification and the implicit assumption that a plan or instruction, once established, is followed. Possible sources of deviations of the plans and construction work are not taken into account. In conclusion a more thorough risk assessment, quality control and realistic assumptions are needed. This general need of monitoring and verification can be integrated in several steps of the construction chain. In particular, the following recommendations offer some possibilities in how the identified problems could be mitigated:

- The Belorussian authorities should consider a continuous monitoring of model buildings, including the possibility of feed-backing and re-adjustment of calculation assumptions (especially regarding the planned interior temperature which should be increased) by the Ministry of Architecture and Construction.
- It is crucial to improve the qualification of craftsmen and construction workers, paying special attention to aspects of energy efficiency and exactness of installation.
- A continuous quality control during construction and before the final acceptance of construction work is strongly recommended.
- The liability regulations should be adjusted so that liability claims become a feasible and not only hypothetical possibility to request the correction of construction mistakes or an equivalent compensation
- Last but not least, continuous awareness raising of home owners is recommended to remind them of the importance of proper ventilation and heating.

The current state program „Residential construction“ for 2016 – 2020 which was approved by the Council of Ministers of the Republic of Belarus 21 April 2016 determines that all apartment houses will be built in an energy-efficient way by 2020. Furthermore, 20% of all new houses should have the energy efficiency classes A or A+. There will be serious obstacles on the path to achieving this goal if not at least some of the structural problems are solved in the nearest future.

Baltic Environmental Forum Germany
Osterstraße 58
DE-20259 Hamburg
http://www.bef-de.org

Ecopartnership
Talbuhina St. 2
BY-220012 Minsk
http://ecopartnerstvo.by/en