Possibilities to increase the energy efficiency of buildings

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***Abstract* — In the paper the solutions how to decrease the energy consumption for the most common types of buildings in urban areas of The Republic of Moldova using the modern practice of improving energy efficiency are shown. Here we mean modernization measures like thermal insulation and integration of renewable energy sources. A study has been made for the schedule of energy consumption and the losses of energy inside the buildings. Were described the technical possibilities of mounting of such sources as, solar collectors, photovoltaic panels, devices for recovery the waste heat. The optimal operating conditions of renewable and traditional energy sources with subsequent analysis of the effect gained from measures described are submitted.**

Keywords— renewable sources; building efficiency; PV; solar collectors; heat recovery

I. INTRODUCTION

Moldova is a country with limited fossil energy resources. This fact imposes the country as more than 95% of energy consumption to be provided by import. Being a country with limited energy resources, Moldova should use the widest available sources in territory such as renewables. This would help increase the level of energy security. On the other hand, it is necessary to use the innovative technical solutions (so called BAT – best available technologies) in order to have high energy efficiency. Unfortunately, the country's energy consumption is constantly rising and the level of energy efficiency is very low. Today Moldova has energy intensity 2-3 times higher than the average of European countries. This means that for each unit of production is consumed 2-3 times more energy compared to other countries. The main cause is the use of obsolete technologies from the Soviet era and lack of investment for modernization.

In Moldova there are several crucial opportunities to increase energy efficiency. One of them is multi-storey buildings, which is an important energy consumer. Over 60% of all dwelling is situated in Chisinau [1]. The present work presents possibilities for efficient energy use in both existing buildings and new ones under construction or planned.

II. GENERAL CHARACTERISTIC OF ENERGY CONSUMPTION IN MOLDOVA

Moldova consumes around 2,300 ktoe. Distribution by consumption category is shown in Fig. 1.

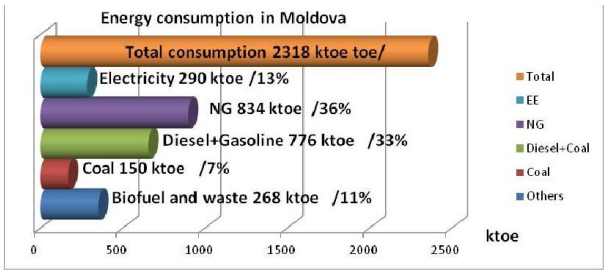

Fig.1. Energy consumption of Moldova for 2013. Source National Bureau of Statistics (NBS)

It should be mentioned that around 50% of all energy is consumed by the residential sector. Over 220ktoe is used as heat supply by district heating, which constitutes 10% of total consumption in the country. Due to the low quality of heat supply services through centralized networks, held major disconnection from the centralized system for moral boiler rooms. Even new buildings constructed focus on individual moral boilers, which results in less efficient centralized system. Another important factor is the high level of heat losses in networks. It reaches 22%.

III. BUILDING CHARACTERISTICS OF CHISINAU MUNICIPALITY

The current situation on buildings from Chisinau is presented in Table 1.

Table 1. Structure of residential and nonresidential buildings by story category

Residential buildings	3521	Nonresidential buildings	5092
1-2 floors	2207	General education school	168
3-4 floors	250		
5 floors	713	Preschool institutions	152
9 floors	248	Other education institutions	65
6,7,8,10, 15 floors	55		
12-14 floors	9	Cultural institutions	99
16 and higher floors	39	Medical institutions	436
		Commercial units	3760
		Industrial factories	281

Analysis of the consumption data shows that over 150ktoe or about 1500kGCal are consumed by these buildings from centralized heating networks [2] and nearly as much energy is consumed by individual heating systems powered by natural gas. The buildings in Chisinau

are responsible for over 20% of total energy consumption in the country, which means a major potential for efficient energy consumption.

At the same time, the buildings have different periods, varying between 0 and 50 years. Building age distribution is shown in Fig. 2.

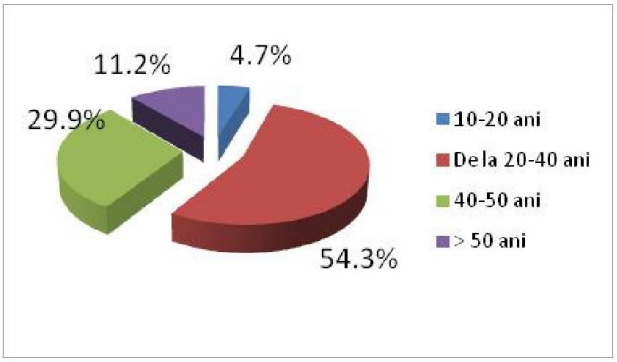

Fig.2. Buildings characteristics by age in Chisinau

It should be noted that most buildings are without thermal insulation and the windows are large energy losses, and a good part of the windows are of low quality with heat losses substantial and are mounted without respecting technologies, which resulted in create thermal bridges.

IV. Estimation of Energy Losses in Buildings

Much of the existing buildings in Moldova are between 20-60 years old and their thermal characteristics are low. On average 75% of energy is consumed for heating buildings. To estimate the energy losses in buildings we will focus on multi-storey buildings constructed of reinforced concrete, which constitutes over 30% of all buildings. We consider an apartment building with nine floors and two staircases. Such blocks have approximately 500 m^2 and 72 apartments. The energy consumption of these apartments is approximately 180kWh/m^2 year, which is 3 times more than in EU countries [3].

For this type of building are characteristic energy losses through walls (U value) of 1.8 W (m^2K), through the windows of 3.3 W (m^2K), through roof of 0.73 W (m^2K).

Typical distribution of energy losses through the constructive elements of the building are shown on Fig. 3.

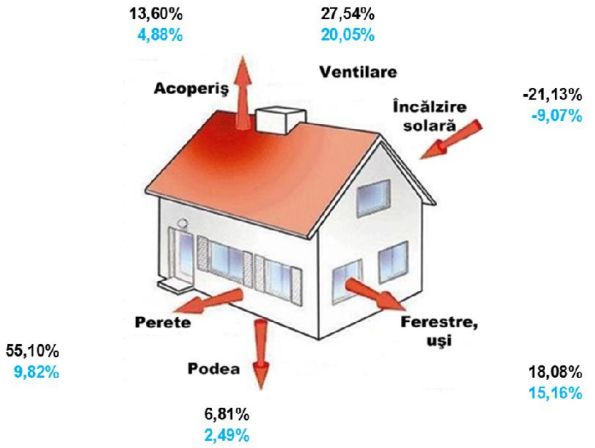

Fig.3. Typical distribution of energy losses through constructive elements of building

In Figure 3 you can see that the biggest losses of energy are through walls (they can reach 50%) and windows (ranging between 15-30%).

Another source of energy loss is the domestic hot water. On average, each family consumes around 3m^3 of hot water per month. In total per year a block of flats consumes around 2592 m^3 of hot water. This means around 99GCal.

V. Efficiency Measures for Energy Consumption in Buildings

The first measure urgently needed to be implemented is the thermal rehabilitation of buildings shell both residential and nonresidential. This measure requires huge investments (around 660 mln. Euros according to [4]) and it is clear that without the implementation of investment projects at the Central Public Authority or/and Local Public Authority will not be easy. If we implementing measures related to building insulation it is possible to cut energy losses by up to 40%. Overall, for existing buildings energy losses can be reduced on average by at least 30% only by thermal rehabilitation of buildings shell. This value would be about 500 thousand GCal.

A second measure would be replacing of one-pipe internal thermal distribution system by two-pipe heating system, metering each apartment, ensuring the possibility of regulating the temperature in each room as needed and the financial strength of tenants.

As next measure it is necessary to implement in every residential block of individual thermal points (ITP). This would exclude transport losses which are around 20%.

Keeping the current tariff for heat from implementing efficiency measures will create a surplus of money that can be directed towards paying investments.

Another category of measures can be recovery of waste heat from canalization. To this end it is necessary to install waste heat recovery systems for sewer pipes that can be redirected back to the individual thermal points for DHW.

A. Using of RES in energy circuit of buildings

One of the possibilities to reduce traditional energy consumption is using of renewable sources for both heat production and electricity. As mentioned above, the roof surface of two staircase 9-story building is approximately 500 m^2. To estimate the amount of energy produced by solar collectors or photovoltaic panels will use this information presented in Table 2.

Table 2. Level of daily insolation in Moldova according to zones

Average indicators for last 22 years	m.u.	**Jan**	**Feb**	**March**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sept**	**Oct**	**Nov**	**Decem**
Drochia	kWh/m^2/day	1.69	2.56	3.15	3.49	4.71	4.19	4.48	4.40	3.14	2.44	1.39	1.44
Bălţi	kWh/m^2/day	1.19	2.18	3.42	4.48	5.65	5.89	5.83	5.05	3.71	2.24	1.27	0.93
Taraclia	kWh/m^2/day	1.19	2.18	3.42	4.48	5.65	5.89	5.83	5.05	3.71	2.24	1.27	0.93
Chişinău	kWh/m^2/day	1.08	1.78	2.68	3.87	5.40	5.70	6.39	5.63	3.96	2.45	1.06	0.87

Based on the data of Table 2 for the estimated amount of energy available monthly on the surface of 500 m^2 (see Fig. 4).

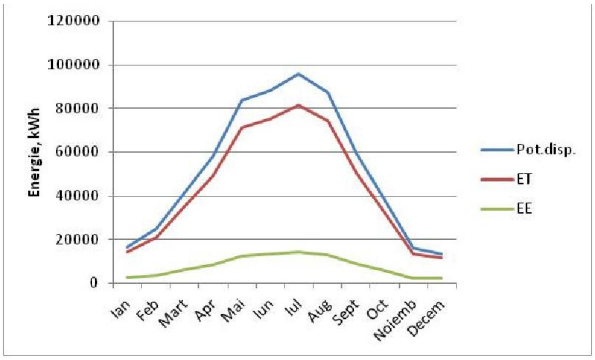

Fig.4. Available energy potential on surface of 500m^2. ET – thermal energy; EE – electrical energy.

From Fig. 4 it is evident that the use of solar collectors with an efficiency of 85% in July we can get an amount of 81 000 kWh of thermal energy and 14 400 kWh of electricity by using photovoltaic panels. Since maximum heat produced from this area is 70GCal in July, while house consumption is 99GCal / year or about 10Gcal / month, it is obvious that the rational is using only an area of the roof for heat production and the rest for electricity.

It should be noted that the location of solar collectors on the roof need to be used in combination with heat-insulated water tanks. This would enable the use of a large area of solar collectors and thus using part then we have cloudy days without sunshine. On the other hand, the size of the tanks could be calculated that during the spring-autumn season to provide tenants with hot water.

The overall area of solar collectors must be calculated so as not to exceed the energy consumption for hot water by tenants. Otherwise it is necessary to implement additional solutions for the storage or use of the water. Remaining available surface may be covered with photovoltaic panels. Also available side surfaces can be used for installing the panels and connecting them to the electricity supply system.

For new constructed buildings it is necessary by law to require implementation and use of renewable energy in the building's heating circuit. Under the new requirements, new buildings are built with insulation and double-glazed windows, which raises their energy efficiency compared to the old model, at least 30%. For new buildings it is possible to use and geothermal energy. The thermal load which can be obtained by horizontal collectors can be considered to be 25 W m^2. So, in an area of 500m^2 we fail to provide a heat load 12,5kW. Thus, in one year can obtain around 82 000 kWh with a heat pump which has a COP of at least 4. This energy is equivalent to 70Gcal / year or 71% of total consumption of thermal energy for DHW. In this case, it is necessary to use this energy for the heating season, and during the warm geothermal plant can use the element of air conditioning. This application would essentially reduce electricity consumption.

VI. Conclusions

By implementation of efficiency measures to existing buildings both residential and non residential we would reduce energy consumption by at least 30% or 300ktoe. On the other hand, the use of renewable energy for existing buildings could replace around 35% of energy and 45% in new built homes.

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