УДК 624.04 531/534

Mokhamad Dib,
Maurizio Landolfi,
Roman Zavalnyuk

THE PROBLEMS OF THE THERMAL RECONSTRCUTION OF MASS LOW RISE DWELLING

National University of Construction and Architecture, Ukraine
Eutecna Energia (member of OICE), Italia

In this article, energy model of the low rise buildings (called "Khruschevki") is stimulated based on Energy Plus program. Rationale of the 3D model is to achieve energy efficiency and improve the energy performance through thermal insulation and applying to untraditional renewable energy sources instead of gas.

Actuality of the theme. Building sector has huge energy saving potential by reducing its energy consumption. Numerous low rise brick houses 1955-1970 (called "Khruschevki"), was built to oil crisis of 1973 and after , currently require urgent general refurbishment which can be coupled with introduction of energy saving technologies and higher energy performance standards , and this fact opens a window of opportunity for the implementation of energy saving measures in a cost-efficient way [1].

The standardized housing development (called "khruschevki"), occupies large scale territory, in close to Kiev city centers. Today, such kind of housing presents 10-15% of the total housing stock in Ukraine (70 million square meters of the total overall area, approximately 2.2 million apartment or 37 thousand of 5-storey of 60 housing apartment. 6 million square meter of the total overall area were build in Kiev [2].

Technically, these kind of industrialized buildings are not in a good condition owing to its low-quality construction and poor maintenance. Those apartments are tiny, with inconvenient room-planning, low thermal protection, thin walls and other disadvantages caused by lack of funds [3].

Energy efficiency is generally poor. Moisture and mould problems appear in some apartments due to poor thermal insulation. Such buildings typically have very simple outer facade and are now in poor condition, i.e. require urgent refurbishment which can be coupled with introduction of higher energy performance standards. At the same time majority of building stock are not equipped with energy saving measures, such as energy efficient windows, due to

lack of incentives to save thermal energy, which is caused by the absence of metering equipment for hot water and heating in majority in residential building stock [4].

Analysis of the main researches. Based on the analysis of the guidance researches shows the following possible aspects concerning the reconstruction (called "Khruschevki") [2][5]:

- Heightening of attic (without dwellers resettlement) and improvement of the outward buildings view and façade insulation, at the same time. Heightening of attic (with dwellers resettlement) and improvement in finishing of the façades without preplanning of apartments.

- Building on attic with apartments preplanning of the typical storey's, at the same time (for example, project in Kiev, Gokovskova street).
- Raising of attic with preservation of the planning or preplanning of the apartments of building.
- Heightening with continuation - extension of the building.

The scientific novelty of the research. The main purpose of the article is an improvement in engineering and design solutions, equipment, and achieving energy conservation and efficiency in the building.

Practical value of the theme. Further improvement in energy conservation and efficiency in buildings «Khruschevki» in Ukraine should be optimized according to the following parameters:

1. Improving thermal insulation of building envelope.
2. Using untraditional renewable energy sources instead of gas consumption.

Typical floor and attic is built during modernization of old building. Thermal insulated for walls, attic's roof, floor above passage and cold basement and change and replaced new windows.

Description of the model. The model is divided into 3 building sections, 5 typical storey's building with attic, was built in 1972. The area of the floor is around 471 m2 with floor attic 532. Each floor consists of 6 dwelling apartments. There are two type of apartments (3 and 4 rooms).The area of 3 room apartment is about 36 m2 and 4 room apartments is 48 m2. The internal height of the floor is 2.8 m. Plan of series "Khruschevki" 114-24-36 demonstrated drawing 3, is shown as an example. The main façade is oriented to South. Energy efficiency class of the building (E). The thermal resistance values, R_{wall}=1,01m^{2}k/W, R_{window}=0,3 m^{2}k/W, R_{roof}=1,21m^2·k/W, R_{floor}=0,5 m^2·k/W.

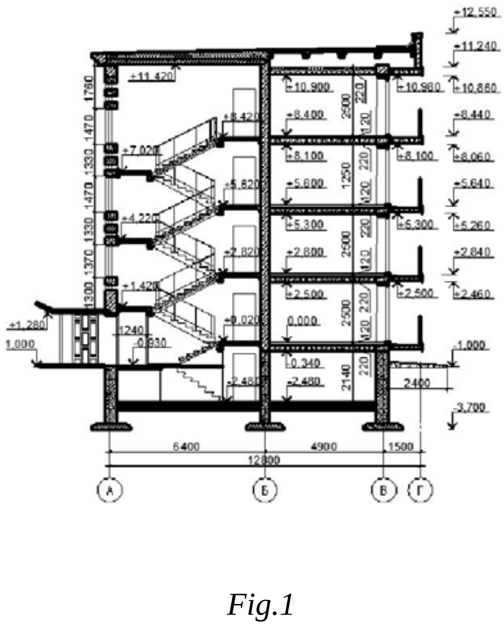


Fig.1
Section of old building envelop

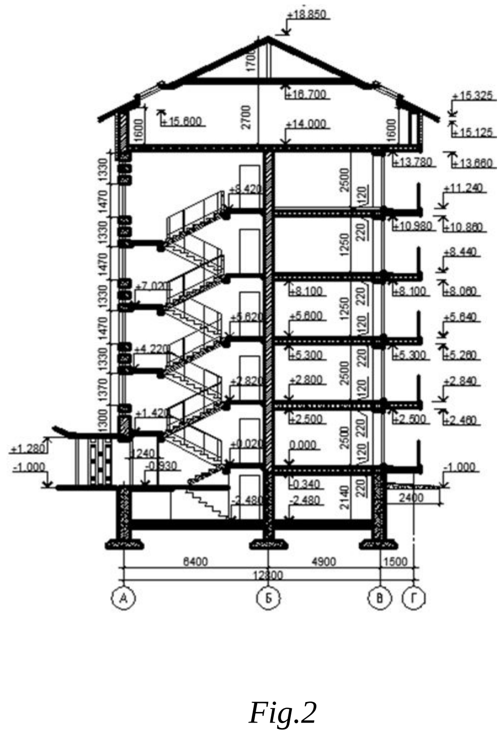


Fig.2
Section of new building envelop

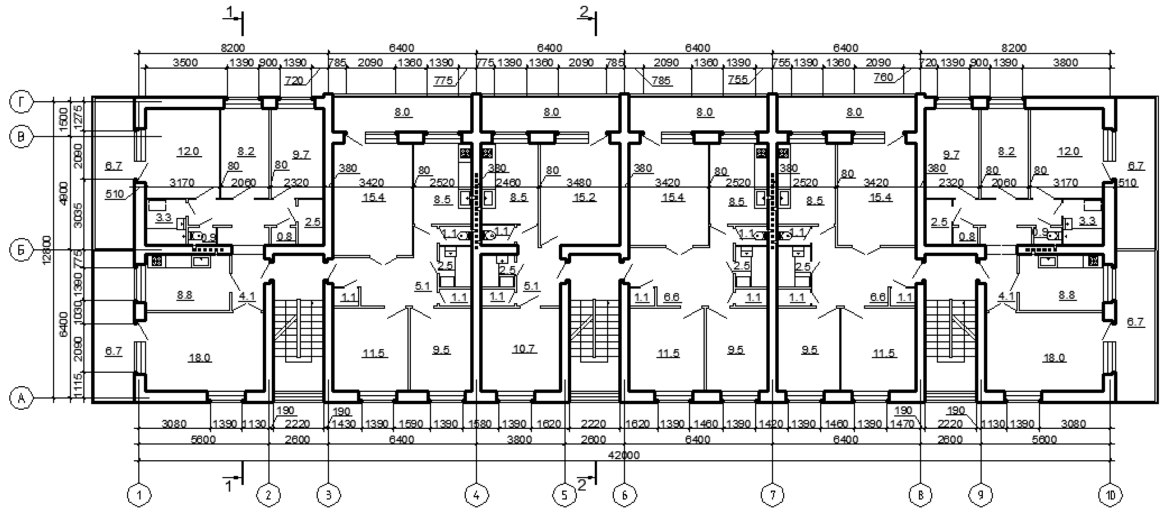


Fig.3 Typical floor plan of the building

Two different scenarios have been conducted intending for reducing energy consumption and greenhouse gas emissions and to ensure sustainable development to include measures to reduce the end use of energy in buildings:

First scenario: thermal insulated the main components of building envelope, changing and replacing windows that provide the (theoretical) maximum profit from capitalized investments and energy cost savings.

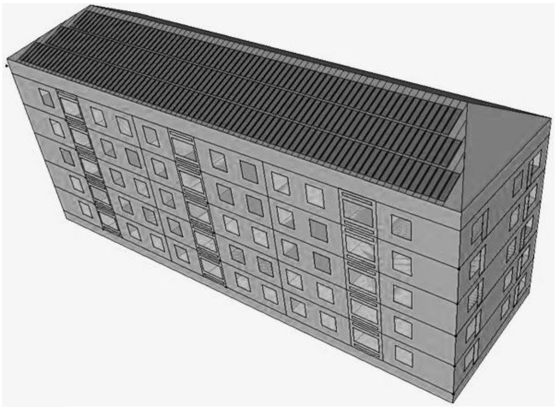


Fig.4 Geometrical 3D model

Table 1.

Old and new value of transmittance and cost of new envelope

	Total	cost x m2 [€]	Total cost [€]	R_{old} [m2k/W]	R_{new} [m2k/W]
Gross Wall Area [m2]	1868.79	25,5	47.659	1,01	4,05
Window Glass Area [m2]	351.48	96,85	34.042	0,3	0,8
Basement[m2]	537.6	25,5	13.709	0,5	4,3
Roof [m2]	582.8	26,3	15.328	1,21	4,5
Total cost [€]			110.738		

Energy consumption is calculated by EnergyPlus simulation tool [6] based on Climatic date [7].

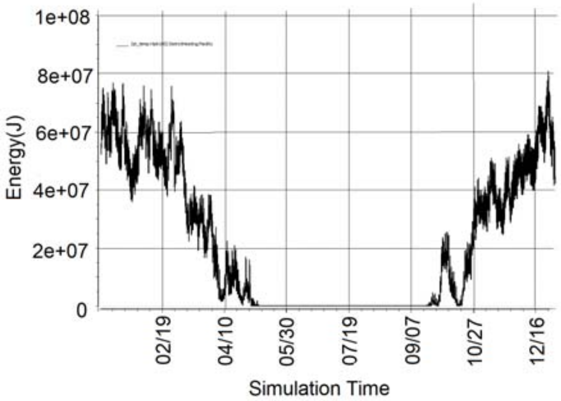
Table 2.

Climate date

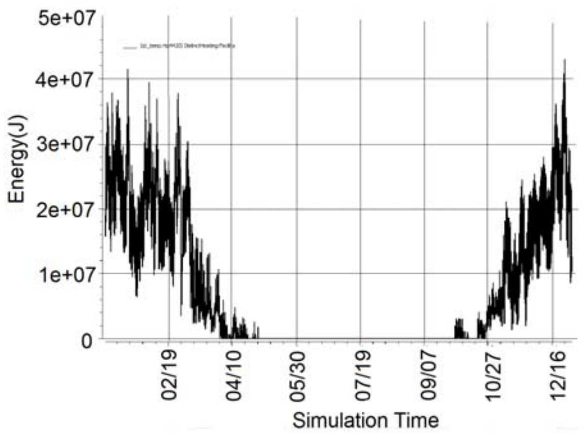
Program Version and Build	EnergyPlus-Windows-OMP-32 7.2.0.006, YMD=2013.04.14 16:14

Weather File	KIEV - UKR IWEC Data WMO#=333450
Latitude [deg]	50.40
Longitude [deg]	30.45
Elevation [m]	168.00
Time Zone	2.00
Setpoint winter temp. [C°]	20

Graphics 1. Comparison of energy consumption

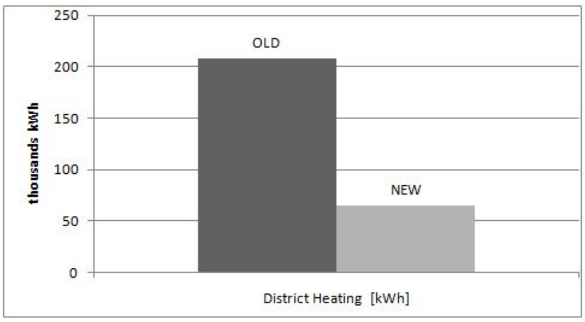


1.1 Energy consumption in old building

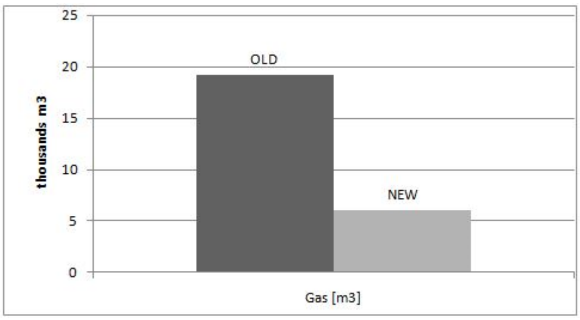


1.2 Energy consumption in new building

Graphics 2. Comparison of energy consumption



2.1 Comparison of energy consumption between old & new building



2.2 Comparison of gas consumption between old & new building

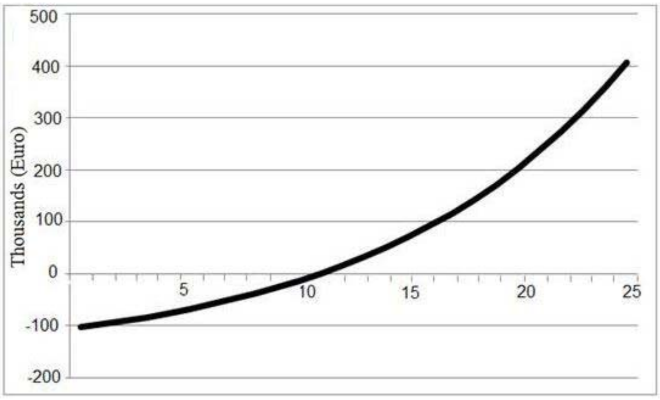
Cost effective: The simulation shows, the heat consumption of old building per year is 19209,5 Nm3 of gas. The total emission of CO2 is 3841,9 Tons per year. The heat consumption of new building is 5993,13 Nm3 per year. 13216,37 Nm3 of gas can be saved every year based on the actual cost of the gas 0,4 € per Nm3 . Accordingly 5286,55 can be saved in the first year. The capitalized investment has been analyzed based on financial parameters in Ukraine take into account cost of money % is 15% , general inflation is 7.4% [8]and Inflation of gas is 17%. [9].Values are gathered over 8760 hours.

Table 3.

Simulation of new and old

Utility Use per year	OLD	NEW	DIFFERE NCE
District Heating [kWh]	208,0 38.89	64,905. 56	143,133.3 3
$Gas \frac{Nm^3}{EURO}$	19,20 9.50 7,683 .80	5,993.1 3 2,397.2 5	13,216.37 5,286.55
CO2 emission [TONN]	3,841 .90	1,198.6 3	2,643.27

Graphics 3. Financial analysis of the first scenario 1



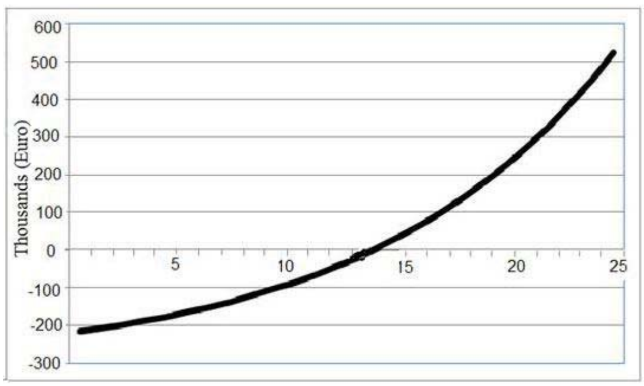
Economic analysis: The capitalized investment cost at the time 0 (start time) is 103161 €.The pay back of the investment will be achieved in 10,7 years, take into account ,25 years is the life cycle of the new thermal insulation. After 25 years the investment will generate a positive value of 405981 €. Total emission of CO2 per year 1,19863 Tons.

Second scenario: using untraditional renewable energy sources instead of gas consumption by combining, thermal insulation envelope as conducted in the first scenario, with geothermal heat pump, radiant system and photovoltaic panels, in order to reduce the energy demand of heating of the building.

According to **[10]** , Geothermal pump, radiant system and geothermal holes will designed to cover 52 KW the peak power heat losses reached in the year's load peak. Concerning **[11]** geothermal pump within 60 kW power. Using earth energy, 10 holes are needed, 100 m each in depth, 1000 m totally. The COP of geothermal heat pump combining with radiant system is between 4 and 5 **[10].**Based on COP, 12,980 kWh/year of electrical energy is needed to supply 64,90556 kWh/year of thermal energy to the building. Electrical energy can be supplied by a photovoltaic system installed on the roof of the building.

Photovoltaic. Based on **[12]**, 1 kWp of optimally inclined modules produces around 1000 kWh per year, in Kiev. That means 12,980 kWh/year of electrical energy can be supplied by 15 kWp photovoltaic panels , installed on the top of the roof of the building, talking into 20 kWp can be installed on the area 240 m2.

Graphics 4. Financial analysis for scenario 2



Economic analysis: The cost of thermal insulation is 103161 €, geothermal pump of power of 60 kw is 18935 €, radiant system for all floors is 29220 €, 10 holes is 19120 € and photovoltaic system is 45000 €. The total cost is 215436 €. The Cost of manpower is included.
Based on *(table 4)* , 19209,50 m3 of gas per year, 7683,8 € will be saved in the first year. Inflation has to be taken into account for next years. Based on graphic .4, the pay back is 13,5 years. The investment return in 25 years is 524633,59 Euro. Total emission of CO_2 per year is 0 kg.

Conclusion. The first variant shows that the returning capital of investment cost during 10,7 years. The second variant during 13,5 years. Second one requires making heavy investments due to the cost of photovoltaic systems. However, the second scenario is to be considered as profitable investments if the geothermal, heat pump and radiant system will consume the electricity produced by solar panels. If the life cycle of "Khruschevki" is considered 10 or 15 years, the first scenario is to be considered as profitable investments. If 25 years, then the second scenario is to be considered as profitable investments. Taking into account not only cost efficiency but also environmental targets, reduced dependency of energy imports etc., these can be a meaningful option, which is realized already in some of the assessed countries.

Bibliography

1. Olena Kiva Energy Efficiency in the residential sector in Ukraine – iiiee ,June 2009.— 63 p.
2. Lodmela Batshenska "Reconstruction's features of 5-story dwelling-houses for the first generation of mass model building" Construction and protection technology/ collection of scientific labors, issued 8/ Simferopol<Crimean academy of nature protection and resort building> 2003 , p.10 – 12 (Translation from Russian).
3. Iryna Stasiuk. Khrouschevki With You, Always. Magazine "Architecture Critics Culture", Edition (3) 2008. – p. 94-103p.(Translation from Russian).
4. Economic Commission for Europe/ country profiles on the housing sector (Russian Federation) /United Nations/New York and Geneva, 2004. – p.33—35 http://www.unece.org.
5. Alexandar Zaytsov "The problem of attic at the reconstruction of residential buildings of first mass construction series" Habitation reconstruction , issued 8 , 2007 114-124 C. (Translation from Ukrainian).
6. EnergyPlus Energy Simulation Software (http://apps1.eere.energy.gov/buildings/energyplus/openstudio.cfm).
7. Climatology in buildings: of DSTO-N B V.1.1-27: 2010 [put into operation 2011-11-01] / MINREGIONBOD of Ukraine. - K. Ukrarkbodinform, 2011. –107 page - (State standard of Ukraine) (Translation from Russian).
8. RBK Ukraine www.rbc.ua/.../inflyatsiya-v-ukraine (Translation from Ukrainian).
9. Short content of energy Strategy 2025 and Municipal energy plan 2011 – 2015.
10. Mokhamad Dib & Maurizio Landolfi. The problems of the thermal

reconstruction of mass low rise dwelling. Published in international scientific, theoretical and practical book of the conference SED-11, (2011) p. 88-94.

11. NIBE Industrial ,www.teplonasos.ua

12. Photovoltaic solar electricity potential in European countries - http://www.renewable-energy-sources.com/wp-content/uploads/2012/09/pvgis_Europe-solar_opt_publication.png

Аннотация

В статье приводится анализ возможностей термореконструкции модели малоэтажки (так называемой "Хрущевки"), для этого была разработана модель на основе программы Energy Plus. Обоснование 3D-модели термореконструированого здания включает в себя: теплоизоляцию и возобновляемые источники энергии.

Анотація

В статті наводиться аналіз можливостей термореконструкції моделі малоповерхівки (так званої “Хрущовки”), для цього була розроблена модель на основі програми Energy Plus. Обґрунтування 3D-моделі термореконструйованої будівлі включає в себе: теплоізоляцію та відновлювані енергетичні джерела.