Technical regulation in low-rise construction in the context of heat supply energy efficient projects

G I Prokofyeva\textsuperscript{1} and N V Gusakova\textsuperscript{1}
\textsuperscript{1}Tomsk State University of Architecture and Building, Department of Economics and Construction Organization, Tomsk, 634003, Russia

E-mail: Gusakovanata@mail.ru

Abstract. The present article is devoted to the problem of energy saving and energy efficiency in construction industry and solving the issues of technical regulation and development of the sufficient regulatory basis. Economic calculations have been performed to study the influence of energy efficient heat sources and application of energy saving ventilation systems on the total operation costs. The efficiency of their use has been proved. The use of energy efficient heat sources and energy saving ventilation systems allowed significant reduction of utility expenses providing comfortable living conditions for the residents.

1. Introduction
Reduction of energy intensity of the national economics is one of major issues that Russia faces today. Construction industry in Russia consumes 40 – 45% of the entire energy output. Currently heating of 1 m\(^2\) of living quarters costs Russia 13 liters of standard fuel. At the same time it costs Canada similar to Russia in climatic conditions only 3.5 – 4 liters per year [1]. These conditions determine the relevance of studying energy efficiency in construction in Russia. The amount of energy consumed is planned to be decreased by 30% up to 2016 and by 40% up to 2020 in comparison with basic level of consumption [2] which is accomplishable providing there is substantial development of legislative and technical standards basis. For this purpose it is essential to make arrangements in technical regulation and standardization of energy efficiency.

Federal law No.261 “On energy efficiency and increase in energy performance and on introduction of amendments to several legal acts of the Russian Federation” can be considered the beginning of technical standards basis development [3].

Modern means of technical regulation in construction in Russia is Standards of National Association of Builders (NOSTROY). Integrated programme of development of regulatory documents on energy efficiency and increase of energy performance of buildings and structures has been designed as the result of scientific and development research of the Association. The programme is intended to promote more than 200 regulatory documents on the problem.

Energy efficiency involves systematic approach not only in delivery of energy resources for buildings already being in operation but also application of energy efficient building materials and heat supply system at the point of initial design of the building [4].

2. Experimental
Experience has proven that low-rise construction is most susceptible to application of innovative heat-saving materials and equipment. In this regard, regional investment project of low-rise construction in Tomsk implies:

1. Maximum application of innovative technologies in heat supply for minimal operating costs.
2. Comfortable conditions inside the buildings through installation of most energy efficient and cost efficient ventilation systems.

As the result, the project plans to utilize heat pumps as a basis of heating system and variable air delivery ventilation system that are supposed to ensure up-to-date quality of climatisation of buildings as well as decrease its maintenance costs.
Heat pump utilized in the project is not only a source of heating but air conditioning as well. In winter heat pump accumulates environmental heat to further employ it in the heating process and cold (7 – 9% of which is used for creation of micro-climate in buildings) from driven well in summer. Heat pump allows obtaining of 75 – 84 % of renewable thermal energy free of charge.

Let us consider how exactly application of heat pumps influences utility expenses in low-rise construction. In the table below there is a comparison of utility expenses of a townhouse with heat pump and an apartment with central heating.

**Table 1. Utility expenses of accommodation with local and central heating systems.**

| No. | Index                          | Townhouse (local heating system) | Apartment (central heating system) |
|-----|-------------------------------|---------------------------------|-----------------------------------|
| 1.  | Total area, m²                | 140                             | 66,3                              |
| 2.  | Heating expenses per year, RUR | 6101                            | 23984                             |
| 3.  | Heating expenses per 1m², RUR  | 44                              | 361                               |
| 4.  | Heating expenses per month, RUR| 762                             | 2998                              |

Calculation shows that the cost of 1m² of area covered by central heating is 8,3 times more than the one covered by local heating based on heat pumps.

In the table below there is a comparison of maintenance costs of buildings with local and central heating systems.

**Table 2. Maintenance expenses of accommodation with local and central heating systems.**

| No. | Index                          | Townhouse (local heating system) | Cottage (central heating system) |
|-----|-------------------------------|---------------------------------|---------------------------------|
| 1.  | Total area, m²                | 140                             | 140                             |
| 2.  | Heating expenses per year, RUR | 6101                            | 50646                           |
| 3.  | Saving through heat pump utilization, RUR | 44544                   |                                  |
| 4.  | Hot water expenses, RUR       | 1373                            | 13515                           |
| 5.  | Saving through heat pump utilization for water heating, RUR | 10383                        |                                  |
|     | Total saving (heating, hot water), RUR |                           | 54928                           |

Therefore, total annual cost advantage of local heating system based on heat pumps per building is equal to 54928 RUR, which is equivalent to 9,2 times reduction in operating costs.

Moreover, it is essential to notice that nowadays more and more attention is being paid to two interconnected problems: energy supply and microclimate of buildings. Basing on what has been said previously, traditional approach to climatisation of buildings cannot be acknowledged in economic way.

Traditional systems are rather energy-consuming which means large expenditure of electricity against small refrigeration capacity.

The project is aimed at working out solutions providing decrease in energy consumption and reduction of maintenance costs. Such solutions include installation of ventilation system with recuperation of energy. The system is most fit for kindergartens, schools, cottages which can accommodate system of air supply pipes, recuperator and exhausting system. Major disadvantage of ventilation system with recuperation of energy is imbalance in air supply and exhaust currents leading to loss of efficiency of recuperation.

We applied another solution – variable air volume ventilation system (VAV-system). This system allows regulating air supply in each room independently. VAV-system with 550m²/h performance is sufficient for a middle-sized cottage. Ventilation system is split into 2 sections with separate control shutter.

System’s cost including equipment and installation is inconspicuously higher but it allows saving up to 50% of electricity spent for ventilation.

Let us compare maintenance cost of ventilation system with recuperation of energy and variable air volume ventilation system.
Table 3. Calculation of cost efficiency of maintenance expenses.

| No. | Index                                                                 | Ventilation system with recuperation of energy | Variable air volume ventilation system |
|-----|----------------------------------------------------------------------|-----------------------------------------------|----------------------------------------|
| 1   | Total thermal energy ventilation expenditure, kW per year            | 8190                                          | 7793                                   |
| 1.1 | System of heat disposal (degree of efficiency – 70%) kW per year    | -                                             | 5455                                   |
| 1.2 | Heating with central heat supply system, kW per year                | 8190                                          | 2337                                   |
| 1.3 | Ventilation electricity expenditure, kW per year                    | -                                             | 431                                    |
| 2   | Total thermal expenditure, kW per year                              | 4550                                          | 2338                                   |
| 3   | Total annual electricity expenditure, kW per year                   | -                                             | 431                                    |
| 4   | Maintenance costs, RUR per year                                     | 7772                                          | 3202                                   |
| 4.1 | Including electricity by 1,82 RUR per kW                           | -                                             | 784                                    |
| 4.2 | Thermal energy by 0,949 RUR per kW                                  | 7772                                          | 2218                                   |
| 5   | Total saving provided by VAV-system                                 | -                                             | 4570                                   |

Therefore, total saving of VAV-system utilization is 4570.5 RUR which exceeds saving of ventilation system with recuperation of energy by 2.4 times.

3. Conclusions

The calculation results showed that when applying heating pump systems heating cost per 1 m² of the total floor area is reduced by 8.3 times in comparison with central heating system.

The application of local heating system and hot water supply system would lead to economy per one house of total surface area 140 m² and will comprise 54,928 RUR per year.

Application of economic ventilation systems for the same house makes the economy of 4570 RUR and enables to reduce the utility expenses by 2.4 times per year.

In conclusion, application of ecologically efficient heating system and modern sources of ventilation allow:

- Reducing total expenditure of thermal energy spent for heating, ventilation and hot water supply compared to annual expenditure in accordance with basic level of energy efficiency requirements.
- Reducing emissions of pollutants into the atmosphere supporting environmental protection.
- Reducing utility payments, transform them into autonomous ones which means independent of energy resources price rise.
- Creating efficient microclimate conditions simultaneously with reducing maintenance costs.

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