Evaluation of savings on operational services from innovative energy-saving materials

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Abstract. Innovative infrastructure projects, as a rule, are aimed at creating or some modification of infrastructure objects, which are characterized by large-scale, high degree of capital intensity, their long-term implementation, freezing investments for a long period due to a long payback period. The most fertile post for the implementation of infrastructure projects is construction. A high share of the economic effect is explained by the fact that the modern world is focused on increasing the efficiency of each innovation, thereby saving on the costs of natural resources, which affects environmental stabilization and the rational use of the resources received. In this aspect, investments in green building can be considered particularly advantageous, allowing us to talk about the double effect of innovations in construction: here we can also reduce the environmental burden on nature with the help of new technological solutions at the stage of development and application of new environmentally friendly materials (effect for the manufacturer), and comfort for a consumer of highly environmentally friendly construction products in an environmentally friendly area (effect for the buyer) in a large metropolis.

1. Introduction
Modern problems of the implementation of innovative materials in green building P.G. Grabovy (2012), O.V. Maksimchuk, O.A. Baulina (2017), etc. Energy technologies and materials have been of interest to modern researchers for more than ten years. So, Pronin S.A. (2001) introduces the concept of innovation in the technical features of green building.

Rauter and others (2018) and Pavlatos and Kostakis (2018) reviewed open innovation and its impact on economic efficiency and innovation activity. A.N. Larionov (2008, 2009, 2011, 2012) argues that environmental friendliness and economic efficiency are factors in the investment attractiveness of housing construction.

At the third stage, the good condition of all structural elements and systems of the building are maintained and the adjacent territory is improved or developed. Any building, regardless of the form of ownership and location, must be under constant maintenance to ensure normal functioning during the entire life cycle, which can reach one hundred and more years (Jiang 2012; Xie 2011; Romanova and others 2015).
Li and others (2018) showed the implementation of architecture, technologies and systems into a Smart Home. Gao and others (2017) addressed the theory and practice of intelligent collection of data on the operation of residential buildings by the example of modern technologies in smart district heating system.

Thus, an important and urgent task in the field of environmental construction is the implementation of a package of measures for the rational use of energy resources.

2. Materials and Methods

This article discusses the main parameters of the effectiveness of the application of environmental construction technologies (mainly resource saving) and the formation of the economic effect of the use of these technologies.

3. Results

Conditional calculations were carried out on the individual residential building basis (author's vision and approach). An average area of house is 100 sq. m, a family of four lives in the house. The average electricity consumption per month is presented in Table 1.

Table 1. Average electricity consumption of an individual residential building of 100 sq. m area for a family of four (authors vision and approach).

| #  | Household appliances list                      | Consumer Power, W | Use mode                              | Consumption, kW |
|----|-----------------------------------------------|-------------------|---------------------------------------|-----------------|
| 1  | Fridge, economy class                         | 100-300           | constantly                            | 60              |
| 2  | Automatic washing machine, 6kg                | 2000-2500         | 4-6 times per week (mainly mode -     | 30              |
|    |                                               |                   | standard wash at 40 degrees,          |                 |
|    |                                               |                   | sometimes up to 80 deg.)             |                 |
| 3  | TV - 2pcs                                     | 80-140            | TV is turned on for 5-6 hours a day   | 35              |
|    |                                               |                   | 4 burners, 2 of which are used        |                 |
|    |                                               |                   | constantly, oven                      | 62              |
|    |                                               |                   | unstable                              | 2               |
| 4  | Electric stove                                | 2000              | TV is turned on for 5-6 hours a day   | 35              |
| 5  | Exhaust hood                                  | 250               | TV is turned on for 5-6 hours a day   | 62              |
| 6  | Microwave                                     | 600-1200          | TV is turned on for 5-6 hours a day   | 35              |
| 7  | Notebook - pc, Mobile Phone 3 pcs, Wi-fi router, DVD player | 300-500          | TV is turned on for 5-6 hours a day   | 62              |
| 8  | Kettle Thermo + to 5L                         | 3000              | TV is turned on for 5-6 hours a day   | 35              |
| 9  | Iron / vacuum cleaner                         | 400-2000          | TV is turned on for 5-6 hours a day   | 62              |
| 10 | Landline phone                                | 1                 | TV is turned on for 5-6 hours a day   | 35              |
|    | (On charging tube)                            |                   | TV is turned on for 5-6 hours a day   |                 |
| 11 | Watches - Service                             | 1                 | (With vibration and city lights)      | 0.7             |
|    | recharging the batteries 2-4 times a month    |                   |                                       |                 |
| 12 | Camcorder, camera                             | 12                |                                       | 3               |
| 13 | Lighting                                     | 700-1500          | 4 bedrooms, bathroom, toilet, hall,   | 60              |
|    |                                               |                   | kitchen                               |                 |
|    | Total monthly electricity consumption         |                   |                                       | 312.4           |

A family of four consumes 312.4 kW of electricity for household needs. The use mode of household appliances is various. For example, a fridge is used constantly, an iron and a vacuum cleaner are used 3-4 times a week on average.
Table 2 shows the electricity tariffs for the period from 2009 to 2018. There is a cost increase dynamic of 1 kW by 0.16 rubles in a year on average.

Table 2. The electricity tariffs for 2012-2018 in the Republic of Tatarstan.

| Year | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|------|------|------|------|------|------|------|------|
| The cost of 1 kW / rubles | 2.06 | 2.23 | 2.33 | 2.43 | 2.88 | 2.99 | 3.20 |
| Cost increase, rubles | - | 0.17 | 0.1 | 0.1 | 0.45 | 0.11 | 0.21 |

Consequently, a family of four pays 999.68 rubles per month on average for consumed electricity per month in 2018.

To switch to solar panels, it is necessary to carry out some preparatory works: average monthly consumption in the summer and winter, determine capital investments, and determine how much our facility will depend on an alternative energy source.

We select a solar battery for an individual residential building, with an area of 100 sq. m, with an average monthly energy consumption of 312.4 kW.

Daily consumption of 312.4 / 30 = 10.41 kWh.

Define the maximum and minimum insolation values for the Kazan city are given in Table 3.

Table 3. The average monthly level of insolation (solar radiation) in Kazan.

| # | Month     | The solar radiation level indicator, kWh / sq. m |
|---|-----------|-----------------------------------------------|
| 1 | January   | 0.68                                          |
| 2 | February  | 1.44                                          |
| 3 | March     | 2.82                                          |
| 4 | April     | 4.29                                          |
| 5 | May       | 5.52                                          |
| 6 | June      | 5.93                                          |
| 7 | July      | 5.72                                          |
| 8 | August    | 4.49                                          |
| 9 | September | 2.86                                          |
| 10| October   | 1.51                                          |
| 11| November  | 0.83                                          |
| 12| December  | 0.54                                          |

The table shows that the highest value of the solar radiation was in June, and the smallest one was in December.

Let us determine by the formula (1) the amount of energy that a solar battery can generate each month of the year.

\[ W = k \times P \times E \]  

(1)

P – the power of the panel, kW;
E – insolation value, kWh /sq. m

To determine an energy amount that solar panel can generate, you need to know the power of the panel. When analyzing the solar panel market, we found that 500W panels have the greatest demand. We calculate the energy amount that this panel can allocate.

The calculation of the energy amount that the solar panel can generate is presented in Table 4.
Table 4. An energy amount calculation that a solar panel can generate

| #  | Month   | The solar radiation level indicator, kWh / sq. m | P, kW | W, kW |
|----|---------|-------------------------------------------------|-------|-------|
| 1  | January | 0.68                                            | 0.5   | 0.34  |
| 2  | February| 1.44                                            | 0.5   | 0.72  |
| 3  | March   | 2.82                                            | 0.5   | 1.41  |
| 4  | April   | 4.29                                            | 0.5   | 2.145 |
| 5  | May     | 5.52                                            | 0.5   | 2.76  |
| 6  | June    | 5.93                                            | 0.5   | 2.965 |
| 7  | July    | 5.72                                            | 0.5   | 2.86  |
| 8  | August  | 4.49                                            | 0.5   | 2.245 |
| 9  | September| 2.86                                           | 0.5   | 1.43  |
| 10 | October | 1.51                                            | 0.5   | 0.755 |
| 11 | November| 0.83                                            | 0.5   | 0.415 |
| 12 | December| 0.54                                            | 0.5   | 0.27  |

Table 4 shows that the solar panel works most efficiently from March to September since in these months there is a high insolation rate.

Based on this calculation, presented in table 4, you can determine the need for solar panels for each month of the year. To do this, daily consumption is divided by the obtained values. The requirement calculation for solar panels is presented in Table 5.

Table 5. Calculation for solar panels requirements.

| #  | Month   | Daily intake, kW | W, kW | N, pcs |
|----|---------|------------------|-------|--------|
| 1  | January | 10.41            | 0.34  | 30.62  |
| 2  | February| 10.41            | 0.72  | 14.46  |
| 3  | March   | 10.41            | 1.41  | 7.38   |
| 4  | April   | 10.41            | 2.145 | 4.85   |
| 5  | May     | 10.41            | 2.76  | 3.77   |
| 6  | June    | 10.41            | 2.965 | 3.51   |
| 7  | July    | 10.41            | 2.86  | 3.64   |
| 8  | August  | 10.41            | 2.245 | 4.63   |
| 9  | September| 10.41           | 1.43  | 7.28   |
| 10 | October | 10.41            | 0.755 | 13.79  |
| 11 | November| 10.41            | 0.415 | 25.09  |
| 12 | December| 10.41            | 0.27  | 38.56  |

At the initial stage, it is proposed to purchase 5 panels, since such an amount will be enough to completely replace energy needs in the summer, and excess electricity will be accumulated and consumed if necessary.

For installation, we select a set of solar modules CNH 500-W-72P with power parameters - 500 W and voltage - 48 V. The set description of solar panels is given in Table 6.
Table 6. Kit description of solar battery CNH 500-W-72P.

| #  | Accessories                          | Price per unit, rubles | Quantity, pcs | Cost, rubles |
|----|--------------------------------------|------------------------|---------------|--------------|
| 1  | Solar modules 500W / 48V             | 16 500                 | 5             | 82 500       |
| 2  | Batteries DELTA GX 12-200            | 29 300                 | 1             | 29 300       |
| 3  | Uninterruptible power supply 24 / 48V| 18 500                 | 1             | 18 500       |
| 4  | The inverter IC-48-1500              | 13 100                 | 1             | 13 100       |
|    | Total                                |                        |               | 143 400      |

We calculate the energy amount that the selected solar panel set can generate. The calculation of the energy amount that the selected CNH 500-W-72P kit can generate is shown in Table 7.

Table 7. An energy amount calculation that a kit of solar panel CNH 500-W-72P can generate.

| #  | Month   | N, pcs | W₁, kW | W₅, kW |
|----|---------|--------|--------|--------|
| 1  | January | 5      | 0.34   | 1.7    |
| 2  | February| 5      | 0.72   | 3.6    |
| 3  | March   | 5      | 1.41   | 7.05   |
| 4  | April   | 5      | 2.145  | 10.725 |
| 5  | May     | 5      | 2.76   | 13.8   |
| 6  | June    | 5      | 2.965  | 14.825 |
| 7  | July    | 5      | 2.86   | 14.3   |
| 8  | August  | 5      | 2.245  | 11.225 |
| 9  | September| 5    | 1.43   | 7.15   |
| 10 | October | 5      | 0.755  | 3.775  |
| 11 | November| 5      | 0.415  | 2.075  |
| 12 | December| 5      | 0.27   | 1.35   |

Based on this calculation, we can calculate the savings from the use of solar panels. The calculation of savings is presented in Table 8.

Table 8. Calculation of savings when using work out a kit CNH 500-W-72P.

| #  | Month    | W₅, kW | Daily energy savings, kW |
|----|----------|--------|--------------------------|
| 1  | January  | 1.7    | 8.71                     |
| 2  | February | 3.6    | 6.81                     |
| 3  | March    | 7.05   | 3.36                     |
| 4  | April    | 10.725 | -0.315                   |
| 5  | May      | 13.8   | -3.39                    |
| 6  | June     | 14.825 | -4.415                   |
| 7  | July     | 14.3   | -3.89                    |
| 8  | August   | 11.225 | -0.815                   |
| 9  | September| 7.15   | 3.26                     |
| 10 | October  | 3.775  | 6.635                    |
| 11 | November | 2.075  | 8.335                    |
| 12 | December | 1.35   | 9.06                     |

Based on this calculation, it is clear that the most efficient use of solar panels occurs in the summer period (April, May, June, July, August). In these months, it is proposed to completely switch to the use of solar panels and then we will save 1562 kW per year. (312.4 kW * 5 month).

In dynamics, the cost of electricity will grow by 16 kopecks per year, this can be seen in Figure 1.
After analyzing the development dynamics of the cost of 1 kW of electricity, we can calculate the economic effect of using solar panels in the summer (April, May, June, July, August). Electricity consumption for a year without using a set of solar panels is 3 748.8 (312.4 kW * 12 months). When using the selected set, the energy consumption per year is reduced by 1 562 kW per year and will be 2186.8 kW, based on this, it is possible to calculate the energy savings. The calculation of savings when using the CNH 500-W-72P kit is presented in Table 9.

Table 9. Calculation of savings by the solar panel kit usage.

| Year | Electricity consumption per year, kW | Consumption cost, rubles | Electricity consumption per year when installing solar panels, kW | Consumption cost, rubles | Savings by the solar panel kit usage, rubles |
|------|-------------------------------------|--------------------------|---------------------------------------------------------------|--------------------------|---------------------------------------------|
| 2015 | 3748.8                              | 11996                    | 2186.8                                                       | 6997.8                   | 4998.4                                      |
| 2016 | 3748.8                              | 12596                    | 2186.8                                                       | 7347.6                   | 5248.3                                      |
| 2017 | 3748.8                              | 13196                    | 2186.8                                                       | 7697.5                   | 5498.2                                      |
| 2018 | 3748.8                              | 13796                    | 2186.8                                                       | 8047.4                   | 5748.2                                      |
| 2019 | 3748.8                              | 14395                    | 2186.8                                                       | 8397.3                   | 5998.1                                      |
| 2020 | 3748.8                              | 14995                    | 2186.8                                                       | 8747.2                   | 6248                                        |
| 2021 | 3748.8                              | 15595                    | 2186.8                                                       | 9097.1                   | 6497.9                                      |
| 2022 | 3748.8                              | 16195                    | 2186.8                                                       | 9447                     | 6747.8                                      |
| 2023 | 3748.8                              | 16795                    | 2186.8                                                       | 9796.9                   | 6997.8                                      |
| 2024 | 3748.8                              | 17394                    | 2186.8                                                       | 10147                    | 7247.7                                      |
| 2025 | 3748.8                              | 17994                    | 2186.8                                                       | 10497                    | 7497.6                                      |
| 2026 | 3748.8                              | 18594                    | 2186.8                                                       | 10847                    | 7747.5                                      |
| 2027 | 3748.8                              | 19194                    | 2186.8                                                       | 11196                    | 7997.4                                      |
| 2028 | 3748.8                              | 19794                    | 2186.8                                                       | 11546                    | 8247.4                                      |
| 2029 | 3748.8                              | 20393                    | 2186.8                                                       | 11896                    | 8497.3                                      |
| Year | Electricity consumption per year, kW | Consumption cost, rubles | Electricity consumption per year when installing solar panels, kW | Consumption cost, rubles | Savings by the solar panel kit usage, rubles |
|------|-------------------------------------|-------------------------|---------------------------------------------------------------|-------------------------|-----------------------------------------------|
| 2030 | 3748.8 | 20993 | 2186.8 | 12246 | 8747.2 |
| 2031 | 3748.8 | 21593 | 2186.8 | 12596 | 8997.1 |
| 2032 | 3748.8 | 22193 | 2186.8 | 12946 | 9247 |
| 2033 | 3748.8 | 22793 | 2186.8 | 13296 | 9497 |
| 2034 | 3748.8 | 23393 | 2186.8 | 13646 | 9746.9 |
| 2035 | 3748.8 | 23992 | 2186.8 | 13996 | 9996.8 |
| 2036 | 3748.8 | 24592 | 2186.8 | 14345 | 10247 |
| 2037 | 3748.8 | 25192 | 2186.8 | 14695 | 10497 |
| 2038 | 3748.8 | 25792 | 2186.8 | 15045 | 10747 |
| 2039 | 3748.8 | 26392 | 2186.8 | 15395 | 10996 |

From the calculation, we can see that the amount of savings increases each year, due to the increase in the cost of 1 kW. By 2025, the selected kit will be used to cover the initial cost of acquiring it, but do not forget that the first 25 years the solar panel is 100% in use, and 80-90% in the next 20 years, therefore, the cost in subsequent years it will only increase, which can be seen in Figure 2.

![Figure 2](image-url)  
Figure 2. The rising cost of energy consumption from the solar panel kit usage with a cumulative total.

We consider the calculation of energy savings and cash costs during the usage of the energy-saving lamp for 100 sq. m. area house. The calculation bases on the fact that the lamp is turned on 6 hours a day (180 hours per month). It is also believed that 1 energy-saving lamp of 20 W in terms of light output is
equal to an incandescent lamp of 100 W. A comparative analysis of an incandescent lamp and a compact fluorescent lamp is presented in Table 10.

Table 10. Comparative analysis of incandescent and compact lamps fluorescent tubes.

|                          | Incandescent lamp | Compact fluorescent lamp |
|--------------------------|-------------------|--------------------------|
| The cost of the lamp, rubles | 10                | 150-200                  |
| The light output of the lamp, kW | 0.1              | 0.02                     |
| Operating time, hour     | 1000              | 8000-15000               |
| Operating period lamp when used 180 hours per month, month | 1000 / 180 = 5.6 | 8000 / 180 = 44.4 |
| Operating period lamps when used 180 hours per month, year | 0.5              | 3.7                      |
| The cost of 1 kW / h, rubles | 3.2              | 3.2                      |
| Cost of electricity per month, rubles | 57.6 + 10 = 67.6 | 11.52 + 180 = 191.52 |
| Energy costs for the first year, rubles | 3.2 * 180 * 12 * 0.1 + 10 * 2 = 711.2 | 3.2 * 180 * 12 * 0.02 + 180 = 318.24 |
| Savings by the use of energy-saving lamps for the first year, rubles | 711.2 – 318.24 = 392.96 |
| Energy costs for the second year, rubles | 3.2 * 1.05 * 180 * 12 * 0.1 + 10 * 2 = 745.76 | 3.2 * 1.05 * 180 * 12 * 0.02 = 145.152 |
| Savings by the use of energy-saving lamps for the second year, rubles | 745.76 – 145.152 = 600.608 |
| Energy costs for the third year, rubles | 3.36 * 1.05 * 180 * 12 * 0.1 + 10 * 2 = 762.048 | 3.36 * 1.05 * 180 * 12 * 0.02 = 152.409 |
| Savings by the use of energy-saving lamps for the third year, rubles | 766.048 – 152.409 = 609.639 |
| Energy costs for three years, rubles | 711.2 + 745.763 + 762.048 = 2219.011 | 318.24 + 145.152 + 152.409 = 615.801 |
| Savings by the use of energy-saving lamps for three years, rubles | 2219.011 – 615.801 = 1603.21 |

The cost of a standard incandescent lamp varies from 5 to 10 rubles. For the calculation, we took the average price of 10 rubles. The cost of an energy-saving lamp varies from 150 to 250 rubles. It is 25 times more expensive than an incandescent lamp.

The operating time of a standard incandescent lamp is 1000 hours on average. The operating time of a compact fluorescent lamp is about 8000-15000 hours. For calculation simplicity, we took the minimum time set by the manufacturer.
Based on these data and the fact that we use a lamp for 180 hours a month, we can calculate the approximate operating time of each lamp. This is six months for an incandescent lamp and almost 4 years for an energy-saving lamp.

When calculating energy consumption per month, we see that the cost of energy-saving lamps is almost 2.9 times higher than that of an incandescent lamp. At first glance it is ineffective, but when calculating for a year, the savings from using energy-saving lamps are 393 rubles. Since the energy-saving lamp has a service life of 3.7 years, the savings from its use will increase, with each year and the third year of operation it will be 1603 rubles per lamp.

The calculation presented in Table 11 is carried out during the operation of the lamps during the year.

| #   | The name of a room | The number of lamps in the room, pcs | Costs of using an incandescent lamp per year, rubles | Costs of using an energy-saving lamps per year, rubles |
|-----|--------------------|--------------------------------------|---------------------------------------------------|-----------------------------------------------------|
| 1   | Living room №1     | 5                                    | 3556                                              | 1591.2                                               |
| 2   | Living room №2     | 3                                    | 2133.6                                            | 954.72                                              |
| 3   | Living room №3     | 2                                    | 1422.4                                            | 636.48                                              |
| 4   | Living room №4     | 3                                    | 2133.6                                            | 954.72                                              |
| 5   | Bathroom           | 3                                    | 2133.6                                            | 954.72                                              |
| 6   | Restroom           | 3                                    | 2133.6                                            | 954.72                                              |
| 7   | Hallway            | 3                                    | 2133.6                                            | 954.72                                              |
| 8   | Kitchen            | 5                                    | 3556                                              | 1591.2                                               |
|     | **Total**          |                                     | **19202.4**                                       | **8592.48**                                         |

To carry out this calculation, the average number of lamps in an individual residential building was determined. An economic benefits analysis was made for using energy-saving lamps after a year of service. For a year of using energy-saving lamps, it is possible to save 10610 rubles with an average price of one lamp of 180 rubles. In previous calculations, we determined that the average service of an energy-saving lamp is 3-3.5 years. The cost calculation of working for both types of lamps is in Table 12.

| #   | The name of a room | The number of lamps in the room, pcs | Costs of using an incandescent lamp per year, rubles | Costs of using an energy-saving lamps per year, rubles |
|-----|--------------------|--------------------------------------|---------------------------------------------------|-----------------------------------------------------|
| 1   | Living room №1     | 5                                    | 11095                                             | 3079                                                |
| 2   | Living room №2     | 3                                    | 6657                                              | 1847.4                                              |
| 3   | Living room №3     | 2                                    | 4438                                              | 1231.6                                              |
| 4   | Living room №4     | 3                                    | 6657                                              | 1847.4                                              |
| 5   | Bathroom           | 3                                    | 6657                                              | 1847.4                                              |
| 6   | Restroom           | 3                                    | 6657                                              | 1847.4                                              |
| 7   | Hallway            | 3                                    | 6657                                              | 1847.4                                              |
| 8   | Kitchen            | 5                                    | 11095                                             | 3079                                                |
|     | **Total**          |                                     | **59913**                                         | **16627**                                           |

Overall savings: 59913 – 16627 = 43286
For 3 years of operation of energy-saving lamps, it is possible to save 43288 rubles, with an initial investment of 4860 rubles (27 lamps * 180 rubles).

Another innovative development of our time is energy-saving windows. By purchasing energy-saving windows, the buyer receives a large number of advantages: you can more effectively keep heat in the house, in the winter they return up to 90% of the heat waves from heating devices; have improved thermal insulation characteristics, thereby helping to keep warm in the house and save on heating; reduce exposure to ultraviolet rays: in the summer the room does not overheat, paintings, wallpapers and other surfaces do not fade; have high light transmission: the room is also light, as if ordinary windows were installed in it; on such windows, the formation of condensate is practically reduced to zero (due to the optimal surface temperature of the glass unit)

Energy-saving when switching to energy-saving windows occurs in three directions:
1) in winter, heating costs are reduced;
2) in the summer, air conditioning costs are reduced;
3) reduced lighting costs in the daytime. [3]

In an individual house with an area of 100 sq. m, there are six window openings, it is proposed to replace wooden windows with double glazing with six-chamber ones with a two-chamber double-glazed window 52 mm thick with argon filling (4M1-20Ar-4V1-20Ar-I4).

The area of one window is 1.4 * 1.7 = 2.38 sq. m, the total glazing area is 14.28 sq. m (2.38 * 6).

To calculate the effectiveness of replacing wooden windows, it is necessary to calculate the heat loss through the windows using the formula (2):

$$Q = \frac{S \cdot dT}{R} \quad (2)$$

Q – heat loss through the windows, W * h;
S – total glazing area, sq. m;
dT – temperature difference between indoor and outdoor, °C;
R – the value of thermal resistance between the interior and the street, sq. m * °C / W.

The temperature regime inside the house for calculation we take +20 °C. This mode is the most comfortable for humans. The average monthly air temperature is presented in Table 13.

| #  | Month     | Temperature outside, °C |
|----|-----------|-------------------------|
| 1  | January   | -13,5                   |
| 2  | February  | -13,1                   |
| 3  | March     | 6,5                     |
| 4  | April     | 3,7                     |
| 5  | May       | 12,4                    |
| 6  | June      | 17                      |
| 7  | July      | 19,1                    |
| 8  | August    | 17,5                    |
| 9  | September | 11,2                    |
| 10 | October   | 3,4                     |
| 11 | November  | -3,8                    |
| 12 | December  | -10,4                   |

We need the monthly average air temperature to calculate the temperature difference between the indoor and the street. It was said earlier that it is necessary to replace plastic windows with energy-saving ones to see how much heat loss will decrease. Table 14 shows the thermal resistance values for wooden and energy-saving windows.
Table 14. Thermal resistance values.

| #  | Name                                                | $R_o$, sq. m°C/W |
|----|-----------------------------------------------------|------------------|
| 1  | Double glazed plastic window                        | 0.4              |
| 2  | Six-chamber window with a double-chamber double-glazed window 52 mm thick with argon filling (4M1-20Ar-4V1-20Ar-I4) | 0.945            |

Table 14 shows that in energy-saving windows, the value of thermal resistance is 2 times higher.

Table 15 shows the calculation of heat loss through plastic and energy-saving windows.

Table 15. Heat loss calculation for standard plastic and energy-saving windows.

| #  | Month | Monthly average air temperature, °C | $dT$, °C | $Q_{window}$, Wh | $Q_{window}$, Wh |
|----|-------|-------------------------------------|---------|------------------|------------------|
|    |       | Standard plastic window             |         | 4M1-20Ar-4V1-20Ar-I4 | 4M1-20Ar-4V1-20Ar-I4 |
| 1  | January | -13.5                               | 33.4    | 1192.38          | 504.71           |
| 2  | February | -13.1                              | 33.1    | 1181.67          | 500.18           |
| 3  | March   | 6.5                                 | 26.5    | 946.05           | 400.44           |
| 4  | April   | 3.7                                 | 23.7    | 846.09           | 358.13           |
| 5  | October | 3.4                                 | 23.4    | 835.38           | 353.6            |
| 6  | November | -3.8                               | 23.8    | 849.66           | 359.64           |
| 7  | December | -10.4                              | 30.4    | 1085.28          | 459.38           |

Table 15 shows that heat loss through plastic windows is higher than through energy-saving. Table 16 shows heat losses per day and per month through plastic and energy-saving windows.

Table 16. Heat loss calculation for plastic and energy-saving windows.

| #  | Month | $Q_{window}$, watt * day | $Q_{window}$, watt * month |
|----|-------|--------------------------|---------------------------|
|    |       | Standard plastic window  | 4M1-20Ar-4V1-20Ar-I4      | Standard plastic window | 4M1-20Ar-4V1-20Ar-I4 |
| 1  | January | 28617.12                | 12113.07                 | 858513.6                | 363392            |
| 2  | February | 28360.08                | 12004.27                 | 850802.4                | 360128            |
| 3  | March   | 22705.2                 | 9610.667                | 681156                  | 288320            |
| 4  | April   | 20306.16                | 8595.2                   | 609184.8               | 257856            |

Table 16 shows the reduction in heat loss when replacing plastic windows with energy-saving ones and reveals a general tendency to save in value terms. The calculation of heat loss reduction is presented in Table 17.

Table 17. The calculation of heat loss reduction

| № p/p | Month | $Q_{window}$, kW * month | Heat loss reduction, kW | Savings from reducing heat loss, rubles |
|-------|-------|--------------------------|------------------------|----------------------------------------|
| 1     | January | 858.5136                | 363.392                | 495.1216                               | 1584.39                |
| 2     | February | 850.8024                | 360.128                | 490.6744                               | 1570.16                |
| 3     | March   | 681.156                 | 288.32                 | 392.836                               | 1257.08                |
| 4     | April   | 609.1848                | 257.856                | 351.3288                               | 1124.25                |
| 5     | October | 601.4736                | 254.592                | 346.8816                               | 1110.02                |
| 6     | November | 611.7552                | 258.944                | 352.8112                               | 1128.99                |
| 7     | December | 781.4016                | 330.752                | 450.6496                               | 1442.08                |
| Total |       | 2880.3                   |                         | 9216.97                               |                         |
Heat loss reduction in January of 495 kW, which in cost terms is equal to 1584.389 rubles, in March, heat losses are reduced from 681.156 kW to 288.32 kW, which in cost terms is 1257.08 rubles. Replacing plastic windows with energy-saving ones per year results in a decrease of 2880.3 kW, which in value terms is equal to 9216.97 rubles. Figure 3 shows what savings appear monthly.

![Figure 3. Savings by replacing plastic windows with energy-saving ones.](image)

In this research, it was proposed to replace conventional plastic windows with more energy-efficient ones, whose air resistance coefficient is higher, replace fluorescent lamps with energy-saving lamps and calculate the acquisition and savings from the use of solar panels.

It shows the obvious savings from work and services on energy efficiency in housing construction, which allows it to be transferred to the rank of "Green Building".

4. Conclusion

Today, all regions are interested in the development of environmental construction and the rational use of natural resources. A high share of innovations in construction is associated with the permanent task of the state and the ongoing interest of private investors in solving housing problems of the population. Demographic growth in the world entails a solution to the problem of providing housing for all residents. The situation in the construction market has been the high cost of the facilities being built, and they are trying to solve this problem with the help of innovative projects. Cost reduction, quality growth, improved the ergonomic effect, and increased safety is the main directions of the construction industry. The solution of local problems, such as natural disasters, special climatic conditions are also fundamental in several countries. However, the creation of any mass-scale product in any industry requires the construction of a facility where products will be manufactured and stored, which is why the construction innovation market dominates others.

So, Green Building is necessary for the continued existence of mankind, as the population increases every year and with it, the needs increase, which, in turn, will lead to an increase in the production and consumption of electricity.
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