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Study of the Possibility of Transition to More Stringent Energy Efficiency Requirements for Translucent Structures in the Republic of Kazakhstan

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Abstract

The article discusses issues related to improving the energy efficiency of translucent structures (hereinafter referred to as windows) in the construction of buildings in the Republic of Kazakhstan. An analysis of the current regulatory requirements for the thermal insulation of windows and other translucent structures, depending on the climatic conditions of the construction region, was carried out. The authors propose a schematic map of the climatic regions of the Republic of Kazakhstan and stricter values for the thermal resistance of windows depending on the degree-days of the heating period, which will significantly reduce heat loss in buildings and cut heating costs. Calculations of potential energy savings and economic benefits from the introduction of energy-efficient windows are presented, and schemes for the certification and labeling of windows by energy efficiency class are proposed. The work is based on an analysis of national standards and international experience and is aimed at supporting sustainable construction and the implementation of Kazakhstan's climate commitments.

Keywords: energy efficiency; windows; translucent structures; heat transfer resistance; degree days; climate zones; standards

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1. Introduction

In the context of global warming and rising energy costs, energy efficiency issues are becoming a priority in all areas of construction. In the Republic of Kazakhstan (hereinafter referred to as the RK), where climatic conditions vary from sharply continental to harsh arctic, reducing heat loss through external enclosing structures is particularly relevant. In the harsh climate of Kazakhstan, where winter temperatures can drop below −30 °C in some regions, energy efficiency issues are particularly relevant.

The energy efficiency of buildings is a key factor in sustainable development, especially in countries with harsh climatic conditions, such as the Republic of Kazakhstan. Translucent structures, including windows and facades, are one of the main sources of heat loss. Existing regulatory values for window heat transfer resistance do not always meet modern energy conservation requirements. In this regard, there is a need to revise the regulatory framework, taking into account the climatic characteristics of the country and international standards. The purpose of this study is to simplify the schematic map of the climatic region of the Republic of Kazakhstan, justifying the transition to more stringent energy efficiency requirements for windows, and developing proposals for the certification of window products in the Republic of Kazakhstan.

In the Republic of Kazakhstan, as in many other countries, the energy efficiency of buildings is assessed using the specific heat consumption index for heating and ventilation. This index allows for an objective comparison of the energy efficiency of different buildings, as well as verification of their compliance with state regulations and standards. The specific heat consumption indicator is the amount of thermal energy required to heat and ventilate a building during the heating season, expressed in kWh/m^2/year (kilowatt-hours per square meter of total area per year). It is calculated taking into account the climatic conditions of the region, the architectural and structural features of the building, the thermal insulation characteristics of the building envelope, and the efficiency of the engineering systems. This indicator is the main criterion for determining the energy efficiency class of buildings. The lower its value, the better the building retains heat, the less energy is required to heat it, and, therefore, the higher its energy efficiency [1,2].

High heat losses lead not only to increased heating costs but also to an increased load on the country's energy infrastructure. Therefore, the introduction of energy-efficient technologies and the improvement of thermal insulation in buildings are important areas of government policy in the field of construction and ecology.

An analysis of international practices in standardization and certification of energy efficiency indicators in the field of construction, building materials, products, and structures has shown that the most common practice is the certification and labeling of buildings as the end product of construction. In terms of construction products, energy-consuming elements of engineering systems and energy equipment are subject to certification and energy labeling: fans, boilers, air conditioners, etc. Among the elements of enclosing structures, certification and energy labeling for energy efficiency are performed for windows and window products [3,4].

Modern industry produces a large number of ready-made windows for various purposes. To make it easier to navigate such a wide variety of windows, it is customary to classify/label them according to their energy efficiency.

An example of energy efficiency labeling and the energy efficiency class of windows in developed countries is shown in Figure 1.

In the EU, the main criterion for assessing the thermal insulation properties of an envelope structure or envelope element is the heat transfer resistance U, m^2·°C/W, heat transfer coefficient kW/m^2·°C.

Currently, in Kazakhstan, the thermal insulation properties of windows are assessed based on the reduced heat transfer resistance index and classified (Table 1) in accordance with the interstate standard GOST 23166-99 «Window blocks. General technical conditions» [5]:

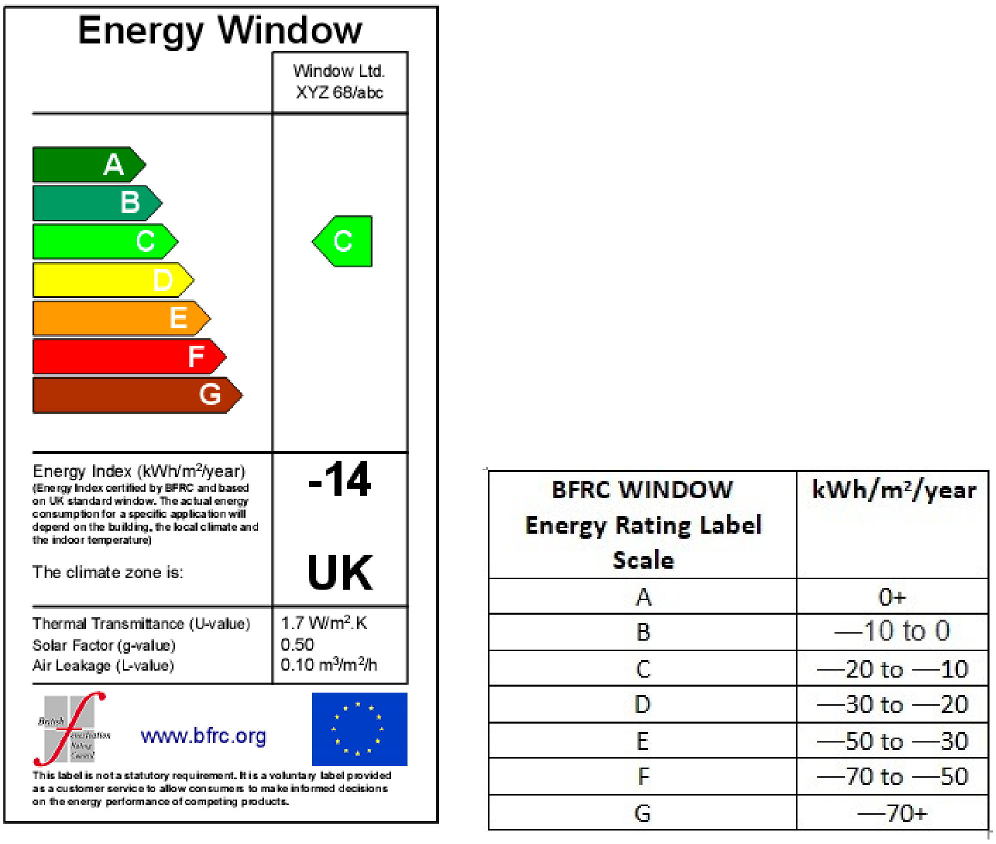
Table 1. Classification of windows and reduced thermal resistance of windows.

No.	Classes	Thermal Resistance, m^2·°C/W
1	A1	0.80 and more
2	A2	0.75–0.79
3	B1	0.70–0.74
4	B2	0.65–0.69
5	C1	0.60–0.64
6	C2	0.55–0.59
7	D1	0.50–0.54

Table 1. *Cont.*

No.	Classes	Thermal Resistance, $m^2 \cdot °C/W$
8	D2	0.45–0.49
9	E1	0.40–0.44
10	E2	0.35–0.39

Note: Windows with a heat transfer resistance below 0.35 m^2 °C/W are not assigned a class. Source: GOST 23166-99.



(**a**) (**b**)

Figure 1. Example of energy efficiency labeling and energy efficiency class of a window. (**a**) Example of energy efficiency. (**b**) Energy efficiency class of windows labeling for windows. Source: open source.

In the Republic of Kazakhstan, one of the key elements affecting heat loss in buildings is external translucent structures—windows, stained glass, doors, facade systems made of glass, and double-glazed windows (hereinafter referred to as windows).

In recent years, the domestic window market has developed quite successfully. Window companies in Kazakhstan are ready to produce energy-saving window structures at a slight increase in cost. Today, medium and small window companies can also manufacture energy-saving windows.

2. Materials and Methods

The work uses regulatory documents of the Republic of Kazakhstan (SN RK 2.04-21-2004, SN RK 2.04-07-2022, SP RK 2.04-107-2022, etc.), climatological data (degree-days of the heating period—Dd), as well as methods for calculating heat loss through window structures. A review of international standards and practices for the certification of window products was carried out. Based on the simplification of the climatic zoning of the territory of the Republic of Kazakhstan, new values for the heat transfer resistance of windows were proposed depending on the degree-days of the heating period. Energy and cost savings were calculated for the use of energy-efficient windows in various climatic zones of the country.

In the Republic of Kazakhstan, issues related to the design of energy-efficient buildings in the field of construction and the assessment of the energy balance of existing buildings are regulated by a number of regulatory documents, in particular:

- Construction standards of the Republic of Kazakhstan (hereinafter referred to as CS RK) CS RK 2.04-21-2004 «Energy consumption and thermal protection of civil buildings» [6], CS RK 2.04-07-2022 «Thermal protection of buildings» [7];
- The set of rules of the Republic of Kazakhstan (hereinafter referred to as SR RK): 2.04-01-2017 «Building Climatology» [8], SR RK 2.04-107-2022 «Thermal Protection of Buildings» [8].

SN RK 2.04-21-2004 sets out the basic regulatory requirements for building design without prescribing how to implement these requirements, providing freedom in design, where it is used as a reference material. The requirements for the thermal protection characteristics of windows, taking into account the climatic conditions in the regions, cities, and settlements of the Republic of Kazakhstan, adopted during the energy assessment of existing buildings in accordance with SN RK 2.04-21-2004, are given in Table 2.

Table 2. Requirements for the thermal insulation characteristics of windows by region, city, and settlement.

No.	Item	Degree Days D_d, °C, Day/Duration of Heating Period, Z_{ht}, Day	Standardized Values of Heat Transfer Resistance SPK Ro_{req}, $m^2 \cdot$ °C/W
Akmola region			
1	Astana	6286/216	0.62
2	Atbasar	6496/218	0.64
3	Kokshetau	6163/217	0.61
Aktobe region			
4	Aktobe	5623/203	0.57
5	Amankeldi	5858/202	0.59
6	Yrgyz	5358/188	0.55
7	Karaulkeldy	4850/188	0.51
8	Wil	4974/187	0.52
9	Shalkar	5057/188	0.53
10	Emba	5187/195	0.54
Almaty region			
11	Almaty	3641/167	0.42
12	Bakanas	4412/173	0.48
13	Zharkent	3623/161	0.42
14	Taldykorgan	4148/175	0.46
15	Usharal	4521/178	0.49
Atyrau region			
16	Atyrau	4160/177	0.46
17	Ganyushkino	3863/174	0.44
East Kazakhstan region			
18	Bakhty	4851/181	0.51
19	Semipalatinsk	5806/203	0.59

Table 2. *Cont.*

No.	Item	Degree Days D_d, °C, Day/Duration of Heating Period, Z_{ht}, Day	Standardized Values of Heat Transfer Resistance SPK Ro_{req}, $m^2 \cdot$ °C/W
20	Zaisan	6587/192	0.64
21	Katon-Karagai	5934/230	0.60
22	Kokpekty	6508/212	0.64
23	Ust-Kamenogorsk	5871/206	0.59
Zhambyl region			
24	Taraz	3477/164	0.41
25	Ulanbel	4001/171	0.45
West Kazakhstan region			
26	Zhympity	5219/194	0.54
27	Taipak	4484/183	0.49
28	Uralsk	5400/200	0.56
29	Zhalpaktal	4719/188	0.50
Karaganda region			
30	Balkhash	5235/189	0.54
31	Zhezkazgan	5432/194	0.56
32	Karagandy	5971/214	0.60
33	Karkaraly	6188/225	0.61
34	Karsakpai	5656/202	0.57
35	Kyzylzhar	5615/197	0.57
Kostanay region			
36	Kostanai	6227/214	0.62
37	Torgay	5782/196	0.58
Kyzylorda region			
38	Aralsk	4582/179	0.49
39	Kazaly	4263/174	0.47
40	Kyzylorda	3965/168	0.45
Mangistau region			
41	Beineu	3758/167	0.43
42	Fort-Shevchenko	3007/155	0.38
Pavlodar region			
43	Ertis	6377/214	0.63
44	Pavlodar	6212/212	0.62
North Kazakhstan region			
45	Petropavlovsk	6571/222	0.64
South Kazakhstan region			
46	Turkestan	3069/149	0.38
47	Shymkent	2660/143	0.35

Source—SN RK 2.04-21-2004 «Energy consumption and thermal protection of civil buildings».

The new standards SN RK 2.04-07-2022 and SP RK 2.04-107-2022 establish requirements for the energy consumption of useful (final) thermal energy for heating and thermal protection of buildings and other indicators of building structures to ensure the microclimate in the building established for human habitation and activity, as well as the necessary reliability and durability of building structures. The standards establish requirements for the minimum values of the reduced heat transfer resistance Ror, $m^2 \times$ °C/W, taking into account the shading coefficient and relative solar radiation transmittance of translucent structures (Table 3).

Table 3. Heat transfer resistance, shading coefficient, and relative solar radiation transmittance of translucent constructions.

		Translucent Constructions					
Filling of the Light Aperture		**In Wooden or PCV Glazing**			**In Aluminum Glazing**		
		R_o^r, $m^2 \times °C/W$	t	k	R_o^r, $m^2 \times °C/W$	t	K
1	2	3	4	5	6	7	8
1	Double glazing of ordinary glass in twin glazing	0.4	0.75/0.7	0.62	--	0.70	0.62
2	Double glazing with hard selective coating in twin glazing	0.55	0.75	0.65	--	0.70	0.65
3	Double glazing of ordinary glass in separate bindings	0.44	0.65/0.6	0.62	0.34 *	0.8/0.6 (0.8)	0.62
4	Double glazing with hard selective coating in separate bindings	0.57	0.65	0.60	0.45	0.60	0.60
5	Glass hollow glass blocks (with joint width of 6 mm) with dimensions, mm: 194 × 194 × 98 244 × 244 × 98	 0.31 0.33	 0.9 0.9		 0.40 (without binding) 0.45 (without binding)		
6	Box section profile glass	0.31	0.9		0.50 (without binding)		
7	Double organic glass for skylights	0.36	0.9	0.9	—	0.90	0.90
8	Triple organic glass for skylights	0.52	0.9	0.83	—	0.90	0.83
9	Triple glazing made of ordinary glass in split-jointed bindings	0.55	0.5/--	0.70	0.46	0.5/--	0.70
10	Triple glazing with hard selective coating in split-jointed glazing bars	0.60	0.50	0.67	0.50	0.50	0.67
11	Single glazing unit in a single pane of glass: plain with hard selective coating with soft selective coating	 0.38 0.51 0.56	 0.8/-- 0.8/-- 0.8/--	 0.76 0.75 0.54	 0.34 0.43 0.47	 0.8/-- 0.8/-- 0.8/--	 0.76 0.75 0.54
12	Double-glazed unit in a single pane of glass: ordinary (with 8 mm glass spacing) ordinary (with 12 mm glass spacing) with hard, selective coating soft, selective coating with hard, selective coating and argon filling	 0.51 0.54 0.58 0.68 0.65	 0.80/- 0.80/- 0.80/- 0.80/- 0.80/-	 0.74 0.74 0.68 0.48 0.68	 0.43 0.45 0.48 0.52 0.53	 0.80/- - 0.80/- 0.80/- 0.80/- 0.80/-	 0.74 0.74 0.68 0.48 0.68
13	Ordinary glass and single glazing unit in separate glass bindings: ordinary hard, selective coated with soft, selective coating with hard, selective coating and argon filling	 0.56 0.65 0.72 0.69	 0.60/- 0.60/- 0.60/- 0.60/-	 0.63 0.51 0.51 0.58	 — — — —	 0.60 0.60 0.60 0.60	 0.63 0.58 0.38 0.58

* In steel bindings. Notes: 1. Soft selective glass coatings include coatings with thermal emission less than 0.15, hard (K glass)—0.15 and more. 2. The values of the reduced resistance to heat transfer of light aperture fills are given for cases when the ratio of the glazing area to the area of the light aperture fill is equal to 0.75. 3. The values of the reduced resistance to heat transfer indicated in the table may be used as design values in the absence of these values in standards or technical specifications for structures, or not confirmed by test results. 4. In the numerator, there are given values t for translucent structures of residential, public, and auxiliary buildings; in the denominator—industrial buildings; in parentheses—for translucent structures with blind glazing. 5. Values for double-glazed windows are given: for wooden windows with a width of 78 mm; for window constructions with 60 mm wide PVC glazing with three air chambers. When using PVC glazing 70 mm wide and with five air chambers, the reduced resistance to heat transfer increases by 0.03 $m^2 \times °C/W$; for aluminum windows, the values are given for glazing with thermal inserts. Source—SP RK 2.04-107-2022 «Thermal protection of buildings».

SP RK 2.04-01-2017 for the construction of buildings establishes the same typological requirements for buildings and structures due to climatic characteristics of territories (types, volume-planning solutions, building orientation, etc.), including for translucent structures (hereinafter referred to as windows). Schematic map of climatic zoning of the territory of the Republic of Kazakhstan for construction is shown in Figure 2.

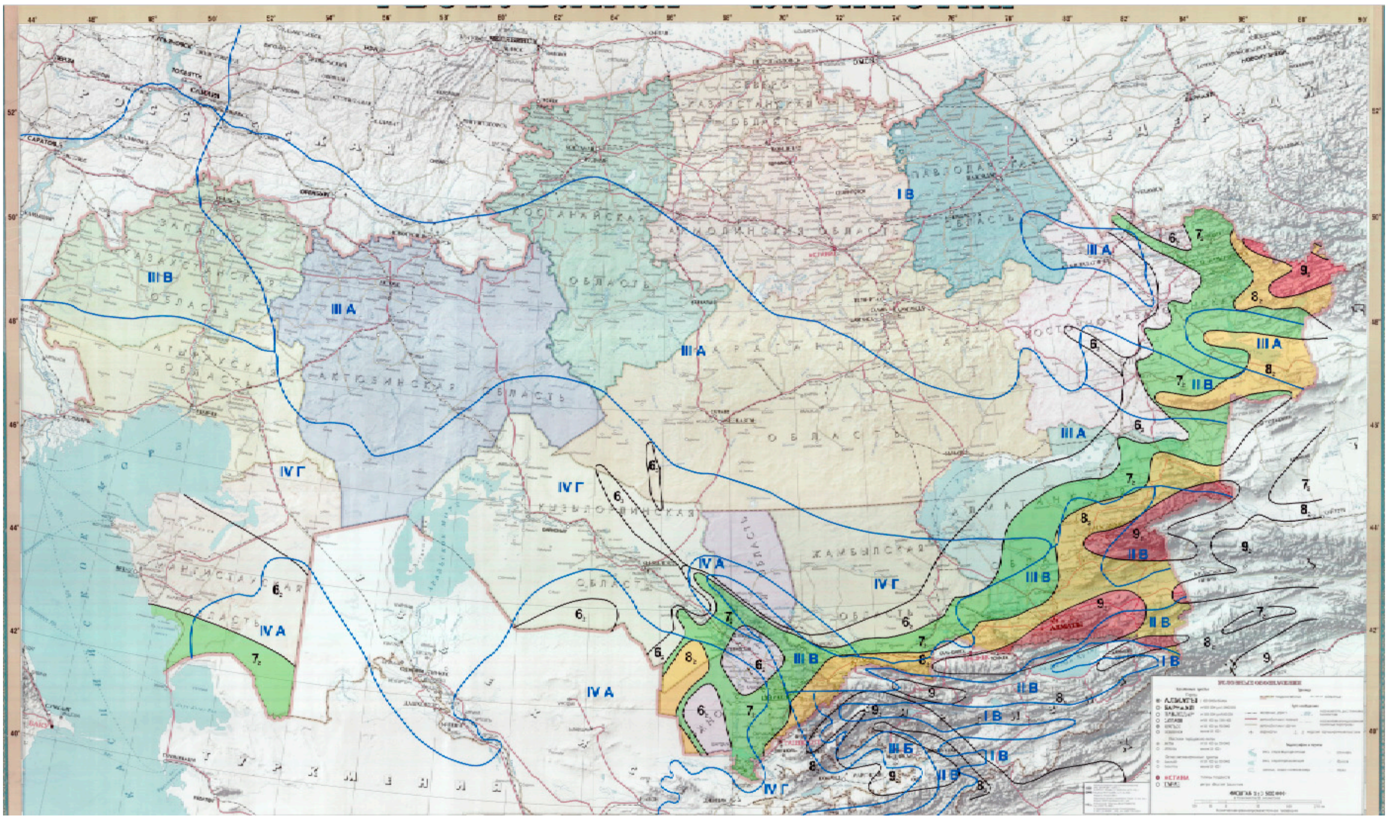


Figure 2. Schematic map of climatic zoning of the territory of the Republic of Kazakhstan for construction. Source—SP RK 2.04-01-2017 (Supplementary Figure S1).

Climatic zoning of the Republic is divided on the basis of combinations of average monthly air temperature in January and July, average wind speed for three winter months, and average monthly relative humidity in July into 4 climatic regions and 16 sub-regions (Table 4).

Climate zone I and subzones IA, IB, IC, ID, and IE are characterized by an average January temperature below minus 14 °C, a short daylight year, a long heating season, low average air temperatures during the coldest five-day periods and days, which necessitate maximum thermal insulation of buildings and protection of buildings and structures from strong winds and high humidity.

Climate zone II and subzones IIA, IIB, IIC, and IID are characterized by an average monthly temperature in January ranging from minus 14 °C to minus 3 °C, a long, moderately warm winter, which necessitates thermal protection of buildings during the long heating season.

Climate zone III with subzones IIIA, IIIB, and IIIC are characterized by an average monthly temperature in January ranging from minus 20 °C to minus 2 °C, increased solar radiation intensity, negative air temperatures in winter, and hot summers, which necessitate thermal protection of buildings during the cold season and protection from excessive overheating during the warm season.

Table 4. Criteria of climatic zoning of the Republic of Kazakhstan.

Climatic Regions	Climatic Sub-Areas	Average Monthly Air Temperature in January, °C	Average Wind Speed for Three Winter Months, m/s	Average Monthly Air Temperature in July, °C	Average Monthly Relative Humidity in July, %
I	IA	From minus 32 and below	—	From 0 to 19	—
	IB	From minus 28 and below	5 and more	From 0 to 13	St. 75
	IC	From minus 14 to minus 28	—	From 12 to 21	—
	ID	From minus 14 to minus 28	5 and more	From 0 to 14	St. 75
	IE	From minus 14 to minus 32	—	From 10 to 20	—
II	IIA	From minus 4 to minus 14	5 and more	From 8 to 12	St. 75
	IIB	From minus 3 to minus 5	5 and more	From 12 to 21	St. 75
	IIC	From minus 4 to minus 14	—	From 12 to 21	—
	IID	From minus 5 to minus 14	5 and more	From 12 to 21	St. 75
III	IIIA	From minus 14 to minus 20	—	From 21 to 25	—
	IIIB	From minus 5 to minus 2	—	From 21 to 25	—
	IIIC	From minus 5 to minus 2	—	From 21 to 25	—
IV	IVA	From minus 10 to 2	—	From 28 and less	—
	IVB	From 2 to 6	—	From 22 to 28	50 and more in 15 h
	IVC	From 0 to 2	—	From 25 to 28	—
	IVD	From minus 15 to 0	—	From 25 to 28	—

Source—SP RK 2.04-01-2017 «Construction Climatology».

Climate zone IV, with subzones IVA, IVB, IVC, and IVD, is characterized by an average monthly temperature in January ranging from minus 15 °C to 6 °C, hot summers with intense solar radiation, relatively short winters with a short heating period, which necessitate thermal protection of buildings during the cold season and protection from excessive overheating during the warm season.

The above standards and tables provide the climatic characteristics of the country's territories and the standard values of heat transfer resistance of external enclosing structures, including windows and other translucent elements. However, most buildings, both in the existing housing stock and in new buildings, are still fitted with window systems that do not meet advanced energy efficiency requirements.

At the same time, we note that the information presented in Tables 2–4 is very dense and difficult to understand, and we select the necessary thermal characteristics of external translucent enclosing structures. It is difficult for a specialist or customer to navigate without experience working with standards, which can lead to errors and misconceptions in the production, design, and operation of buildings.

The review and analysis show that climatic conditions play a decisive role in the selection of window energy characteristics. In this regard, researchers propose to increase the values of the reduced heat transfer resistance of translucent enclosing structures depending on the number of frost days per heating period in the construction area, D_d, °C × day [9–13].

Based on previous research by Yessengabulov S. [14–16], the authors of this article propose to adopt the following values of the reduced heat transfer resistance of translucent enclosing structures depending on the number of frost days during the heating period in the construction area of the Republic of Kazakhstan:

(a) For the construction area, $D_d \leq 3500$ °C × day; instead of a conventional window with R = 0.38 $m^2 \cdot$ °C/W, we propose to use a warm window with R = 0.60 $m^2 \cdot$ °C/W (hereinafter in brackets R = 1.0 $m^2 \cdot$ °C/W):

$$Q_{mid} = (3053 \cdot 0.024)/0.38 - (3053 \cdot 0.024)/0.6 = 71 \text{ kW·h/m}^2 \ (73 \text{ kWh/m}^2)$$

Using the example of the city of Shymkent, with D_d = 2660 °C × day, the annual savings amounted to $Q_{OP} = (2660 \cdot 0.024)/0.35 - (2660 \cdot 0.024)/0.6 = 76$ kW·h/m^2 (119 kWh/m^2). This value in Gcal is 0.065 (0.1) Gcal/m^2.

Accordingly, energy-efficient windows will save up to 440 (700) tenge per heating season.

(b) For the construction area, $D_d = 3500 \div 5200$ °C × day; instead of a conventional window R = 0.50 $m^2 \cdot$ °C/W, we propose using an energy-efficient window with R = 0.8 $m^2 \cdot$ °C/W (hereinafter R = 1.0 $m^2 \cdot$ °C/W):

$$Q_{mid} = (4350 \cdot 0.024)/0.50 - (4350 \cdot 0.024)/0.8 = 89 \text{ kW·h/m}^2 \ (105 \text{ kWh/m}^2)$$

Using the example of the city of Almaty, with Dd = 3641 °C × day, the annual savings are equal to $Q_{OP} = (3641 \cdot 0.024)/0.42 - (3641 \cdot 0.024)/0.8 = 99$ kW·h/m^2 (121 kWh/m^2), which in Gcal is 0.085 (0.1) Gcal/m^2.

Accordingly, it is possible to save up to 573 (700) tenge per heating season.

(c) For the construction area, $D_d \geq 5200$ °C × day; instead of a conventional window with R = 0.60 $m^2 \cdot$ °C/W, use an energy-efficient window with R = 1.0 $m^2 \cdot$ °C/W, and the annual energy savings will be

$$Q_{mid} = (5200 \cdot 0.024)/0.60 - (5200 \cdot 0.024)/1.0 = 97 \text{ kW·h/m}^2$$

Using Astana as an example, with D_d = 6286 °C × day, the more accurate value of annual energy savings per year was

$$Q_{OP} = (6286 \cdot 0.024)/0.62 - (6286 \cdot 0.024)/1.0 = 92 \text{ kW·h/m}^2$$

This value can be converted to Gcal by dividing it by 1163, which gives us approximately 0.08 Gcal/m^2. Based on the heat energy tariff at the time of the study, we can conclude that 1 m^2 of energy-efficient windows can save up to 536 tenge per heating season.

Previous studies by the authors show that investments in translucent structures with improved thermal characteristics pay off within a reasonably foreseeable period of time and prove the profitability of using energy-efficient windows.

3. Results

Based on the calculations performed, it is possible to recommend energy-saving windows with higher thermal characteristics than those specified in the current regulatory documents of the Republic of Kazakhstan; for example:

(a) For construction areas with $D_d \leq 3500$ °C × day, it is recommended to use windows with a reduced heat transfer resistance of $R \geq 0.6$ m^2 × °C/W for construction areas relative to the regions and settlements of the cities of Taraz, Turkestan, Aktau, Shymkent, and the nearest points to them. These characteristics can be accepted for glazing balconies, loggias, and verandas in all climatic regions.

(b) For the construction area with $D_d = 3500 \div 5200$ °C × day, it is recommended to use energy-efficient windows with $R \geq 0.8$ m^2 × °C/W for the construction area relative to the regions and settlements of the cities of Almaty, Aralsk, Atyrau, Bakanas, Bakhta, Beineu, Ganyushkino, Zhalpaktal, Zharkent, Kazaly, Karaulkeldi, Kyzylorda, Taipak, Taldykorgan, Uil, Ulanbel, Usharal, Shalkar, Emba, and the nearest points to them.

(c) For construction areas with $D_d \geq 5200$ °C × days, it is recommended to use energy-efficient windows with a heat transfer resistance of RFr ≥ 1.0 m^2 × °C/W for construction areas relative to the regions and settlements of the cities of Aktobe, Amangeldy, Astana, Atbasar, Balkhash, Ertis, Zhezkazgan, Zhympity, Zaisan, Karaganda, Karkaraly, Karsakpay, Katon-Karagay, Kokpekty, Kokshetau, Kostanay, Kyzylzhar, Pavlodar, Petropavlovsk, Semipalatinsk, Torgay, Uralsk, Ust-Kamenogorsk, Yrgiz, and the nearest points to them.

It has been shown that the use of warmer window systems can save up to 92–119 kWh/m^2 per year, which is 0.08–0.1 Gcal/m^2 and, in monetary terms, up to 700 tenge/m^2 per heating season. A window energy efficiency scale (classes A–G) and certification labeling options are also proposed.

Taking the above into account, the authors conducted a qualitative and quantitative analysis of the differences in terms of the following parameters: readability, ease of use, degree of detail, and energy efficiency. Table 5 presents a comparative table with the current and recommended values of the heat transfer resistance of external translucent structures (windows, stained glass, doors, facade systems) depending on the climatic region of the Republic of Kazakhstan.

Table 5. Current and recommended values of the reduced thermal resistance of external translucent structures (windows, stained glass, doors, facade systems) depending on the climatic region.

Indicator	At Degree-Days of Heating Period RK		
	Up to 3500	**Up to 3500 to 5200**	**5200 and More**
Current normative values of heat transfer resistance of translucent constructions	0.4	0.5	0.6
Recommended values of heat transfer resistance of translucent constructions	0.6	0.8	1.0

Note: From the point of view of building heat engineering, in mountainous areas (including high-mountainous and sharply continental climate zones), it is recommended to apply windows with high heat transfer resistance R = 1.0 m^2 · °C/W, allowing for the minimization of heat losses in harsh climatic conditions. Source—Authors' proposal.

The method proposed by the authors (Table 4) has the following advantages:

Simplification: Reduces all regions to three ranges by degree-day heating period (D_d), instead of dozens of rows and values by population centers;

Energy Efficiency: Increased recommended heat transfer resistance values, which are in line with international best practices;

Ease of implementation: Allows designers and experts to make faster decisions.

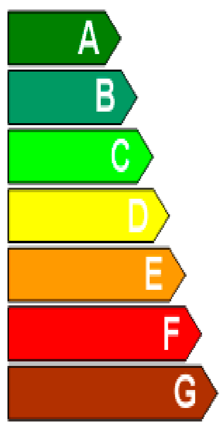
Figure 3 shows the proposed schematic map of the climatic region of the territory of the Republic of Kazakhstan with recommended values of the reduced heat transfer resistance of windows.

Figure 3. Proposed schematic map of the climatic regions of the Republic of Kazakhstan with recommended values for the heat transfer resistance of windows. Authors' proposal.

The transition to stricter energy efficiency requirements for translucent structures in the Republic of Kazakhstan is a necessary step in the context of sustainable development, energy conservation, and the fulfillment of international climate commitments. Given the technical and production readiness, as well as the availability of positive international experience, the introduction of stricter standards can be implemented in stages with the participation of the state, business, and the public. With growing energy shortages and rising energy prices, it is becoming advisable to use heat- and energy-saving translucent structures that retain heat in the room in winter, significantly reducing heat loss.

When certifying translucent structures and windows for energy efficiency, it is possible to use already known certification schemes. Based on a comparative analysis, the advantages of the new window classification and labeling system are proposed, as well as directions for further improvement of the regulatory framework. In Table 6, the authors propose energy efficiency labels and energy efficiency classes for windows.

Table 6. Energy efficiency labels and energy efficiency classes for windows.

Window Energy Efficiency Labels		Window Energy Efficiency Class
Classes	R, $m^2 \times °C/W$	
A	1.0 and more	
	0.95 ÷ 0.99	
B	0.90 ÷ 0.94	
	0.85 ÷ 0.89	
C	0.80÷ 0.84	
	0.75 ÷ 0.79	
D	0.70 ÷ 0.74	
	0.65 ÷ 0.69	
E	0.60 ÷ 0.64	
	0.55 ÷ 0.59	
F	0.50 ÷ 0.54	
	0.45 ÷ 0.49	
G	0.40 ÷ 0.44	
	0.35 ÷ 0.39	

Source—Proposal by the authors.

The choice of scheme will depend on the conditions of its application and the choice of manufacturer (supplier). In Kazakhstan, standards for assessing the energy efficiency of translucent structures, windows, and products must first be developed, and compliance with these standards must then be certified.

4. Discussion

Transition to stricter energy efficiency requirements for translucent constructions in the Republic of Kazakhstan is a necessary step within the framework of sustainable development, energy saving, and fulfillment of international climate commitments. Taking into account technical and production readiness, as well as positive international experience, the introduction of stricter norms can be implemented in stages with the participation of the state, business, and the public.

5. Conclusions

Translucent structures play a significant role in the thermal balance of buildings and require a review of regulatory requirements in the direction of tightening.

Existing regulatory tables contain excessive, complexly structured information, which complicates design and decision-making.

The schematic map of the climatic region of the Republic of Kazakhstan with recommended values for the heat transfer resistance of windows proposed by the authors provides a simpler, more logical, and modern approach to standardizing the thermal protection of translucent structures and windows.

The increased heat transfer resistance values proposed by the authors will significantly improve the energy efficiency of buildings and save resources.

The system, based on climatic gradations by degree-days of the heating period, is convenient for integration into the regulatory framework and certification standards.

The new requirements can be implemented in stages with the participation of the state and manufacturers.

It is necessary to develop and implement a system for certifying and labeling windows in Kazakhstan.

The results of the study can be used to revise the regulatory framework and develop national standards in the field of energy-efficient construction.

To increase transparency and implement the approach, it is necessary to develop methodological recommendations and pilot projects in the regions.

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