TYPOLOGY OF ENVIRONMENTALLY CERTIFIED BUILDINGS AND THEIR ROLE IN THE FORMATION OF THE ARCHITECTURAL SPACE OF RUSSIAN CITIES

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Abstract. The increase in the rate of environmental certification of buildings in foreign countries and Russia makes it necessary to study the role of environmental certification in construction, to highlight the degree of influence of environmental standards on architectural space. Consider the features of architectural shaping of buildings certified according to international and Russian environmental standards, and determine their new typology. In the conducted research, the percentage of architectural and technological requirements of foreign and Russian environmental standards in construction is presented. For the analysis of more than eighty environmentally certified buildings, a graph-analytical tabular form using an assessment matrix is used. The characteristic features of the objects of research are identified, similar features are generalized into groups and systematized. Typical architectural planning and engineering measures that are most often used to improve the environmental friendliness rating are identified. The impact of environmental standards requirements on spatial planning solutions is assessed. Identification of the share of architectural and engineering requirements in the assessment of objects according to environmental standards with the definition of a new typology of environmentally certified buildings is important for further improvement of the national environmental standard and the architectural space of Russian cities.

Key words: environmental certification, environmental standard, green construction, environmental assessment matrix, building typology.

1. Introduction

The deterioration of the ecological situation on the planet, the excessive consumption of natural resources encourages to move to a new level of ecological design is safe for human and nature (Couvelas, 2020; Duisebekova *et al.*, 2020; Tubridy, 2020), regulated environmental standards in construction (Wordena *et al.*, 2020).

Over the last 30 years there has appeared a large number of systems environmental certification for buildings, which set a specific mechanism of work of the designer (Matsui, 2017; Lambrechts *et al.*, 2019). Three environmental certification systems are leaders in the global green construction industry-BREEAM, Great Britain, 1990 (Kamsu-Foguem *et al.*, 2019; Liu *et al.*, 2020), LEED, USA, 1998 (Mazzola *et al.*, 2017), DGNB, Germany, 2009 (Schlegl *et al.*, 2019; López *et al.*, 2019).

The history of environmental standards is primarily associated with the formation of the concept of sustainable development in the middle of the XX century, which implies the protection of the interests of current and future generations while preserving natural resources.

There are international environmental conventions and agreements dealing with climate change in the context of sustainable development in the world: the Paris Agreement on Climate Change - the outcome document of the 21st Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC); the 2030 Agenda for Sustainable Development — the outcome document of the UN Summit on the adoption of the post-2015 development Agenda; the Kyoto Protocol; the Stockholm Convention on Persistent Organic Pollutants.

In 2002, the World Green Building Council WorldGBC was approved, which became a fundamental moment in the development of green construction. There are also Councils of Boverket, GBC, SEI, GSBC, iiSBE dealing with the study of environmental problems and rational use of resources. Their task is to promote ecological methods of design, construction and operation of sustainable facilities.

To date, many countries have adapted international versions of the systems, or developed national environmental standards in construction (Cordero *et al.,* 2020) including Russia (Baba and Anufriev, 2020). The first Russian environmental certification systems began to appear in 2010y, and were more focused on foreign analogues (BREEAM, LEED, DGNB).

Russian green standards include: Corporate Olympic Green Standard; Green Standards NP-SPZS 1.1. M-2011 "Low-rise construction"; SAR-SPZS "Administrative buildings"; STO-NOSTROY 2.35.4-2011 "Residential and public buildings"; GOST R 54964-2012 "Conformity assessment. Environmental requirements for real estate objects"; SDS "RUSO. FOOTBALL STADIUMS"; EcoVillage; GREEN ZOOM "Practical recommendations for reducing energy intensity and improving the environmental friendliness of civil and industrial construction objects. New construction"; PNST 352-2019 Green standards. Green technologies of the living environment. Assessment of compliance with the requirements of green standards. General provisions".

The increasing pace of environmental certification of buildings makes it necessary to study the changing architectural space in more detail (Franco, 2021).

The following methodological research plan is proposed, in which:

- *The object of research* is international and Russian environmental standards for buildings, environmentally certified buildings in Russia according to international and national environmental standards;
- *The subject of the study* is the impact of environmental standards on architectural space;
- *Objectives of the study:* to study the orientation of environmental certification systems in construction; to identify standard solutions for environmentally certified objects; to propose a new typology of buildings certified according to environmental standards.

2. Materials and methods

2.1. Mathematical method for analyzing environmental standards

Using mathematical analysis of requirements, we will determine the significance of architectural and technological solutions in foreign and Russian environmental assessment systems (Fig. 1).

To identify the architecture, it is necessary to calculate the total number of requirements for location, spatial planning and compositional solutions, visual perception, choice of materials and structures, and what is directly taken into account when designing.

The following formulas are used for calculation:

$$100\% \div v_n = k_n, \text{ where}$$

v_n – total number of environmental standard requirements;

k_n – the weight of each requirement as a percentage.

$$A_E = \Sigma_i(OPK+ER+M+KP) \cdot k_n, \text{ where}$$

A_E – number of criteria in % related to the architecture aspect;

OPK – number of requirements for a space-planning and compositional solution;

ER – number of requirements for aesthetic solutions;

M – number of requirements for the use of materials;

KP – the number of requirements for design solutions.

The volume block in each environmental certification system contains requirements for technological processes. We will highlight the requirements for technological solutions in the green standards, using the following formula:

$$T_E = (100\% \div v_n) \cdot T_{ech}, \text{ where}$$

T_E – number of criteria in % related to technological solutions;

v_n – total number of environmental standard requirements;

T_{ech} – the number of requirements for engineering and technological solutions.

2.2. Graph-analytical method for analyzing environmentally certified buildings

Using the graph-analytical method of research, the features of architectural and planning solutions of the studied objects are revealed. The article analyzes architectural plasticity, fundamental compositional patterns (hierarchical subordination, tectonics, architectural scale). Design features, including alternative sources and natural components in the volume are considered.

Table 1. Matrix for evaluating the spatial planning features of an environmentally certified building.

Criteria	Note:	Rating
Influence of climatic parameters		
Insulation	1. Uniform ratio of shading and lighting zones on the facade	+/-
	2. Sunshades in the volume of the structure	+/-
	3. Special plastic volume	+/-
	4. External sun protection	+/-
	5. Internal sun protection	+/-
Wind mode	6. Protection against adverse winds	+/-
	7. Possibility of natural ventilation of the premises	+/-
	8. Wind energy management on the facade	+/-
	9. Volume aerodynamics	+/-
	10. Wind protection on the site (terrain, trees, structural elements)	+/-
Water mode	11. Rainwater collection on the territory	of +/-
	12. Organization of water	bodies +/-
	13. Collecting rainwater from the roof	+/-
Landscaping services	14. On the adjacent territory	+/-
	15. Green roof	+/-
	16. Modular wall system	+/-
	17. Natural components included in volume	+/-
Map item placement		
In the environment	18. Natural	+/-
	19. Urban	+/-
	20. Part of an ensemble	+/-
On the territory of	21. On a flat area	+/-
	22. On difficult terrain	+/-
	23. Elevated	+/-
	24. volumes + / - Buried in the terrain	+/-
Interaction with the environment	25. Bionic forms	+/-
	26. Geometric shapes	+/-
	27. Buffer spaces (terraces, atriums)	+/-
	28. Neutrality of the architectural image (natural, historical context)	+/-
	29. Imitating terrain textures	+/-
	30. Wednesday Disclosure	+/-
	31. Transparency	+/-
Volume form		
Silhouette	32. Rectangular	+/-
	33. Plastic	+/-
	34. Rugged	+/-
	35. Stepwise	+/-
Scale	36. Normal	+/-
	37. Heroized	+/-
	38. False	+/-
Volumetric plastic	39. That is functional and constructive	+/-
	40. Artistic and tectonic	+/-
	41. Decorative and symbolic	+/-
Metric volume pattern	42. Static	+/-
	43. Dynamic	+/-
	44. Mobile	+/-
Tectonics	45. Constructive	+/-
	46. Artistic	+/-
	47. False	+/-
Space-planning solution	48. Compact	+/-
	49. Flattened	+/-

Table 1. Matrix for evaluating the spatial planning features of an environmentally certified building.

Criteria	Note:	Rating
	50. Linear	+/-
	51. Block	+/-
	52. Cellular	+/-
	Facade plasticity	
Large plastic products	53. Parapet	+/-
	54. Wall	+/-
	55. Basement	+/-
	56. Sunken floors	+/-
Roofing system	57. Flat	+/-
	58. Skatnaya	+/-
	59. Curved	+/-
Surface area	60. Structural	+/-
	61. Flat	+/-
	62. Constructive	+/-
	63. Decorative	+/-
	64. Ornamental	+/-
	65. Thematic	+/-
Openings	66. Contour	+/-
	67. Filling	In +/-
	68. Framing	+/-
	69. Vertical profiles	+/-
	70. Horizontal profiles	+/-
Vertical divisions	71. Repeatability of units per 100 m > 10>	+/-
	72. Repeatability of units per 100 m > 50>	+/-
	73. Repeatability of units per 100 m > 100>	+/-
Horizontal partitioning	74. Repeatability of units per 100 m > 10>	+/-
	75. Repeatability of units per 100 m > 50>	+/-
	76. Repeatability of units per 100 m > 100>	+/-
Decorative details	77. Architectural and plastic elements	+/-
	78. Geometric elements	+/-
	79. Missing	+/-
	Layout of the premises	
Design scheme	80. Frame (free layout)	+/-
	81. Frameless (with a wall-bearing frame)	+/-
	82. Mixed type (combined)	+/-
Plan outline	83. Cell	+/-
	84. Bellhop	+/-
	85. Enfilade	+/-
	86. Pavilion	+/-
	87. Hall	+/-
	88. Corridor and ring	road +/-
	89. Cell-hall	+/-
	90. Enfilade-hall	+/-
Plan form	91. Curved	+/-
	92. Oval	+/-
	93. Round	+/-
	94. Rectangular	+/-
	95. Square	+/-
	96. Polygonal	+/-
	97. Complex	+/-
Building a plan	98. Symmetric	+/-
	99. Unbalanced	+/-
	100. Scenic	+/-

Table 1. Matrix for evaluating the spatial planning features of an environmentally certified building.

Criteria	Note:	Rating
	Translucency of the volume	
Glazing system	101. Panoramic	+/-
	102. Fragmented	+/-
	103. Combined	+/-
Transparency / % of closed facades	104. Failure / 0	+/-
	105. Satisfactory / 1-3	+/-
	106. All right / 3-8	+/-
	107. Excellent / 8-10	+/-
Light pollution	108. Buildings that do not produce light pollution at night	+/-
	109. Buildings that produce light pollution at night	+/-
	110. Buildings that "work as a facade" for	illumination +/-
	Facade material	
Wall decoration	111. Small-element structure made of fine facing material	+/-
	112. Krupnoelementnaya from large facing material	+/-
Quality	113. Natural	+/-
	114. Artificial	+/-
	115. Recycled	+/-
	116. Reuse	of +/-
Invoice number	117. Smooth matte	+/-
	118. Smooth Glossy	+/-
	119. Rough	+/-
	120. Grooved	+/-
	121. Cellular	+/-
Color Shades	122. Light	+/-
	123. Dark	+/-
	124. Dark-light	+/-
	125. Neutral	+/-
	126. Bright	+/-
	127. Light and bright	+/-
	128. Dark and bright	+/-
	Use of renewable energy sources	
Use of solar energy	129. Passive	+/-
	130. Active	+/-
Placement of renewable energy conversion devices	131. On the roof	+/-
	132. On the facade	+/-
	133. In the volume structure	+/-
	134. On the territory	of +/-
	135. Combined use	+/-
	Life cycle	
Stability of processes	136. Closed-autonomous (natural reproduction and safe disposal)	+/-
	137. Traditional (citywide communications)	+/-
	138. Combined	+/-
* Note: "+"- the event is used; "-" - the event is not used.		

To highlight the characteristic features of three-dimensional compositional and architectural planning solutions, a matrix for evaluating environmentally certified buildings, Table 1 has been developed (Table 1).

3. Theory

Environmental standards today are a guide to action, a way to educate and get information, but not a way to think (Rheude, 2021). Therefore, often buildings with the highest environmental assessment ratings due to modern technological equipment cannot be called sustainable (Amiri *et al.*, 2021; Lamy *et al.*, 2021).

This method of analysis is necessary to identify the typological features of green buildings and determine the characteristic impact of the requirements of environmental certification systems on the architectural space. The obtained data are summarized and systematized into groups.

The criteria of green standards set a certain mechanism for working with the goal of gaining more points. To certify any building, you must: provide for a number of environmental solutions that meet the green standard; customize design solutions for selected eco-friendly events; evaluate the result to get a specific environmental assessment rating.

There are no contradictions in such an algorithm of actions, if the requirements of the standards equally take into account environmental architectural and planning and engineering and technological measures. However, if the certification system is oversaturated with requirements for implementing efficient equipment, the building may "lose its visually attractive architectural appearance", turn into a "resource-saving machine" that depends on constant energy supply from outside.

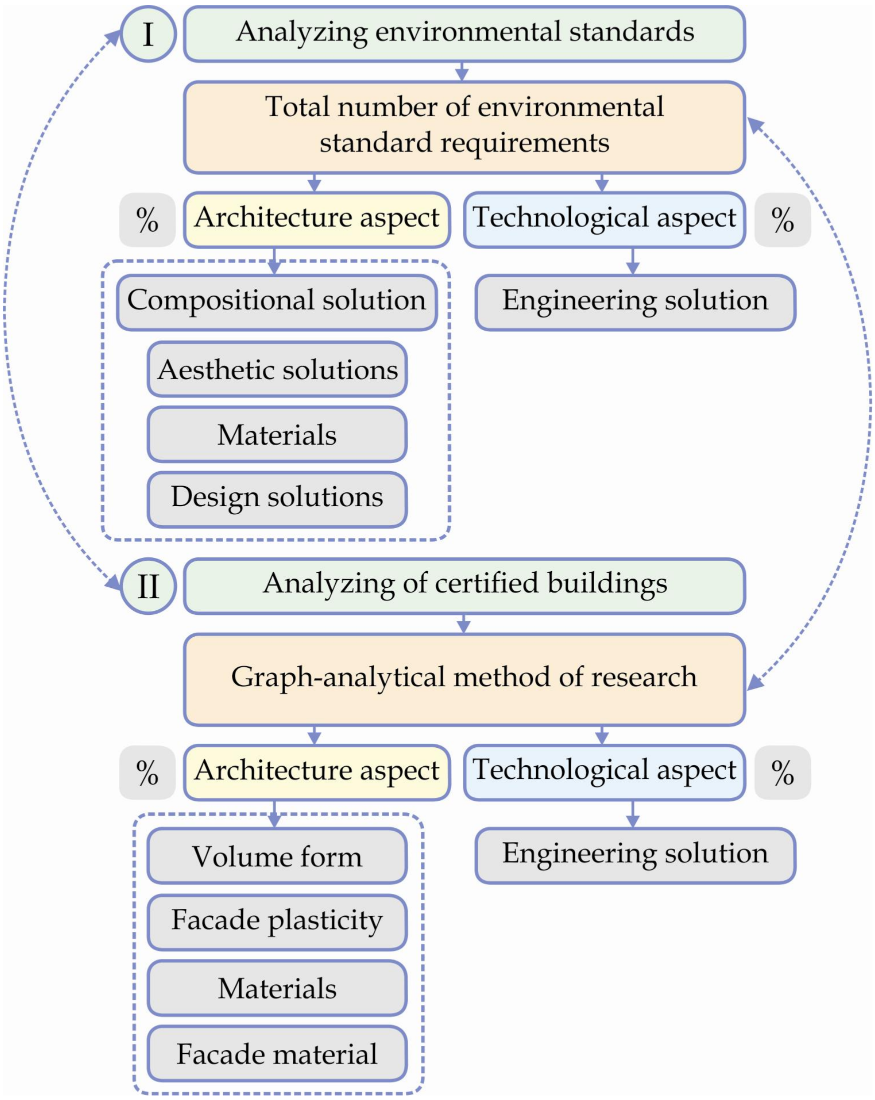


Fig. 1. Flow chart of the used methodology.

For example, the first environmental standards in construction were developed by environmentalists and engineers, they evaluated mainly the "technical" components of the object: territory, transport, energy, water supply, and pollution. The lowest proportion took into account the economic component, socio-cultural values, the functioning of the object and architecture. When environmental certification of any object required project coordinator, they can only be experienced architect versed in the issues of green building (Douglas *et al.*, 2018; Steiner, 2018; Botequilha-Leitão and Díaz-Varela, 2020). In foreign countries, the "integrated design concept" is being promoted, when all designers and specialists are involved in the project implementation from the very beginning, which helps to significantly reduce the cost of green solutions in the future.

Foreign experts have identified the role of the architect-designer in the process of designing an environmentally certified building, which is only 20% in relation to other participants in the process (adjacent sections – 60%, owners and users – 10%, appraisers-auditors – 10%). This indicator is clearly insufficient, since it is the architect who is responsible for the final appearance of the certified object (Donmez-Turan and Kiliclar, 2021).

European and Russian researchers have conducted comparative analyses of environmental standards in construction, highlighting their priority areas (Mattoni *et al.*, 2018; Subhash and Palaniappan, 2019).

One of the first comparisons of the main environmental assessment methods was conducted in 1999, where scientists focused on the construction sector, assessed the environmental sustainability of systems and identified their general trends. In 2008 classification schemes were proposed for building types, users, lifecycle phases, and available databases in the form of graphs, tables, and reports.

In 2015, a comparison of the American and Italian environmental standards LEED and ITACA for residential buildings showed no significant technical differences between the two methods certification methods (Asdrubali *et al.*, 2015). In 2017, after a comparative analysis of BREEAM, LEED, DGNB, HQE, CASBEE, SBTool, foreign researchers found that the most important categories from a quantitative point of view are energy efficiency, solid waste management, materials and water. The lower categories are disaster resilience, earthquake prevention, and olfactory comfort. Standards are more technical in nature and can cover urban-scale projects, public projects, and infrastructure (Bernardi *et al.*, 2017).

In 2018, Swedish scientists compared the performance of BREEAM SE, LEED, Green Buildings, and Miljöbyggnad in terms of human and environmental impacts by integrating life cycle analysis (Turk *et al.*, 2018). Other green building assessment systems were analyzed using statistical analysis to classify loans, quantify them, and compare them at the category level (Ismaeel, 2018). A critical review of the Green Star, LEED and China Green Building rating systems was also conducted to analyze the sustainable design of the building, and it was determined that LEED is focused on energy efficiency, and Green Star pays special attention to project process management (He *et al.*, 2018).

In 2019, the correspondence and correlation between the LEED and BREEAM green building assessment systems was studied LEED и BREEAM (Suzer, 2019). In 2020 с, coranked environmental, social and economic quality in standards the BREEAM, HQE, LEED, CASBEE, DGNB, GB/T, Green Star standards as the most important aspects affecting climate change (Norouzi and Soori, 2020). In 2021, Life Cycle Assessment (LCA) and green building assessment systems were considered as two approaches that are commonly used for holistic analysis of the environmental performance of the entire building (Sartori *et al.*, 2021).

Various multi-criteria evaluation methods in mathematical context, developed by foreign experts, help to conduct combined studies of architectural models using experimental data, quantitative and qualitative assessment of architectural and mathematical indicators (Domínguez-Torres *et al.*, 2022).

In the reviewed scientific studies, the emphasis is placed more on economic, environmental, social issues and methods of evaluating standards. There are not enough studies devoted to the analysis of architectural and technological aspects and the formation of certified objects with their division into types.

4. Results and discussion

4.1. Analysis of the requirements of foreign and Russian environmental standards

In the systems of environmental certification in construction, there are a number of general patterns, the requirements of which affect architectural, technological and design solutions.

Using the mathematical method, we compare the number of requirements for architectural planning and engineering-technological solutions in foreign environmental standards (BREEAM (UK), LEED (USA), DGNB (Germany), CASBEE (Japan) (Table 2).

The English BREEAM standard equally takes into account architecture and technology (29.12%), the American LEED system focuses on high-tech equipment of the building (39.60% of the requirements). The greatest attention to architectural planning, compositional, aesthetic and constructive measures is paid in the documents DGNB (40.80%) and CASBEE (48.10%).

Similarly, we compare the ratio of requirements for architecture and engineering and technological solutions in Russian standards (Green Standard, STO NOSTROY 2.35.4-2011, GREEN ZOOM, PNST 352-2019) (Table 3).

The green standard almost equally takes into account architectural (32.20%) and technological solutions (39.90%). STO NOSTROY 2.35.4-2011 "Residential and public buildings" considers architectural (32.55%) and technological (29.96%) events in almost equal parts. In the GREEN ZOOM standard, "Practical recommendations for reducing energy intensity and improving the environmental friendliness of civil and industrial construction facilities. New construction "there are significantly fewer architectural events (27.56%) than technological ones (42.40%). In the PNST 352-2019 Green standards. Green technologies of the life environment. Assessment of compliance with the requirements of green standards. General provisions "engineering technologies are evaluated more (49.40%) than environmentally friendly planning techniques (22.10%).

Table 2. Analysis of the requirements of foreign environmental standards.

Ecological Standard name	Introduction, year	Estimation objects	Percentage of events, %	
			Architecture (A_E)	Technologies (T_E)
BREEAM	2016	All real estate objects	29,12	29,12
LEED	2018		22,80	39,60
DGNB	2018		40,80	24,48
CASBEE	2001		48,10	38,85
Average value:			35,21	33,01

Table 3. Analysis of the requirements of Russian environmental standards

Ecological Standard name	Introduction, year	Estimation objects	Percentage of events, %	
			Architecture (A_E)	Technologies (T_E)
Green Standard	2017	Buildings, premises, land plot, construction	32,20	39,90
STO NOSTROY 2.35.4-2011	2011	Residential and public	32,55	29,96
GREEN ZOOM	2019	Civil and industrial construction	27,56	42,40
PNST 352-2019	2019	All real estate objects	22,10	49,40
Average value:			28,60	40,42

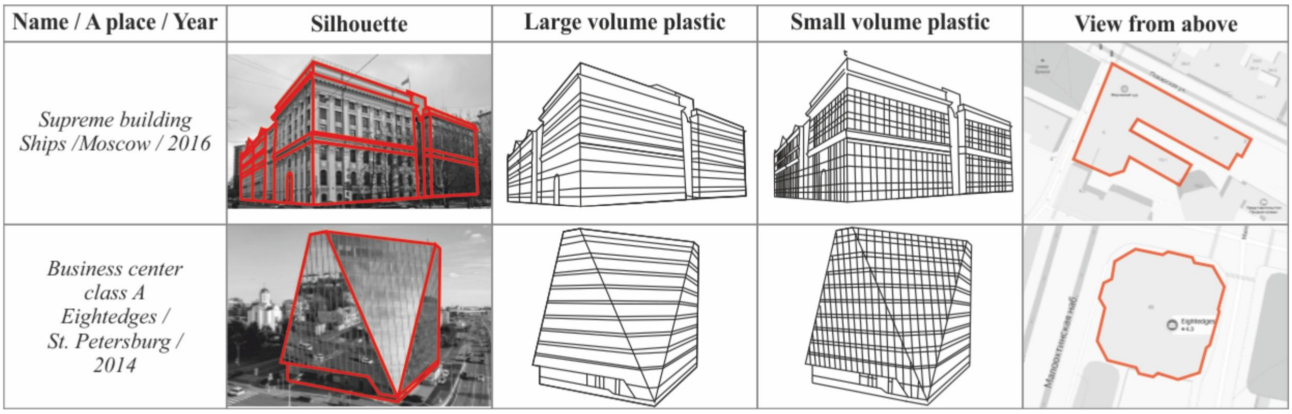


Fig. 2. Example of graphical analysis of objects.

From the above analysis, it can be concluded that the requirements of Russian environmental certification systems should be finalized with an increase in the share of criteria for environmentally friendly architectural and planning solutions that do not depend on energy.

4.2. Graph-analytical analysis of environmentally certified buildings

Using the proposed assessment matrix and graph-analytical analysis (Fig. 2), we will conduct a study of buildings in Russia that are certified according to international and Russian environmental standards. Below are images of some of the analyzed objects, with the results of the numerical evaluation matrix.

For example, the first certified buildings in Russia were associated with automated mechanisms stuffed with electronics (Table 4).

The percentages identified in Table 4 show the share of using ecological architectural and planning solutions, ranging from 25 to 30%.

When assessing *the impact of climate parameters* on the certification object, the following features can be distinguished. All buildings under study take into account favorable orientation and maximum use of natural light. Providing sun protection in the interior of the premises, the possibility of natural ventilation through the window openings becomes possible. Sometimes the removal of the roof and wall plastic is used to create shadow zones. The lack of a sufficient number of green spaces, reservoirs and recreation areas in the surrounding area creates a "heat island effect" on hot days, which negatively affects the microclimate and health of citizens.

The object is placed mainly within the city limits on a flat plot, near significant transport hubs. The buildings are often buried in the ground with basement and courtyard floors. Interaction with the environment is available by maintaining the urban context (scale, shape, plasticity), sometimes due to the transparency of the volume and reflection of the surrounding buildings in panoramic glazing.

When evaluating *the three-dimensional composite solution*, we can conclude that the silhouette of environmentally certified buildings is almost always rectangular, the scale is normal. Bulk plastic – functional and constructive with technical subordination of elements is implied. The metric pattern of volumes is static. Mobility and opening of the object in the environment is very rare, except for some cases of transformation of external shutters or awnings. Volume tectonics is more common with a demonstration of the structural structure. The predominance of geometric shapes of volumes is characteristic. For large megacities, a compact space-planning solution of office and administrative centers, in the form of a high-rise, is typical.

Large *plastic facade* is represented with a predominance of the wall plane, less often with the parapet and basement. The surface of facades is flat in the form of large areas of glazing, less often structural with protruding decorative elements. Openings are mostly marked in the form of a contour and fill, without a dedicated frame. Double-glazed windows have vertical and horizontal profiles. Vertical and horizontal divisions on facades are used with a repeatability of 10-50 units per 100 m. Typical rhythmic rows of geometric elements and divisions prevail on the facades of office centers as a contrast to bionic forms of life-sustaining architecture.

The layout of the premises is mainly corridor-ring. The design scheme of most office centers is a frame structure with a free layout and transformable glass partitions for the variability of the internal space formation. The shape of the plan is rectangular or square, less often curved with a complex configuration, without "picturesque accents". Plan construction is symmetrical or non-symmetrical.

When evaluating *the translucency of the volume*, it should be noted that the glazing is almost always panoramic to maximize the use of natural light, less often combined in combination with standard window openings and light lamps. The area of glazing relative to the facade varies from 30 to 80%. The percentage of closed facades with advertising signs is satisfactory. There is a problem of light pollution, in the dark some buildings "work with the facade" to the light.

Table 4. Analysis of space-planning features of public environmentally certified buildings in Russia

Metropolis Business Center, Moscow, 2009 Certificate: BREEAM In-Use – Very Good. Main purpose: Class A office center, shopping center. Designer: arch. Levyant B., architectural agency ABD	Arkus III Business Center, Moscow, 2014 Certificate: BREEAM International – Very Good. Main purpose: multifunctional office building. Designer: American studio Swanke Hayden Connell Architects	MEBE One Business Center Khimki Plaza, Khimki (Moscow region), 2014 Certificate: LEED-Gold. Main purpose: office center. Designer: JohnMcAslan + Partners
		

Metropolis Business Center

EVALUATION MATRIX					
5	+	7	+	19	+
21	+	26	+	31	+
32	+	36	+	39	+
42	+	45	+	51	+
54	+	56	+	57	+
60	+	66	+	67	+
69	+	72	+	74	+
78	+	82	+	88	+
94	+	95	+	98	+
101	+	105	+	110	+
112	+	114	+	118	+
123	+	137	+	25%	

Arkus III Business Center

EVALUATION MATRIX					
1	+	3	+	5	+
7	+	8	+	14	+
19	+	21	+	26	+
31	+	32	+	36	+
39	+	42	+	45	+
48	+	53	+	54	+
55	+	56	+	57	+
60	+	66	+	67	+
69	+	72	+	74	+
78	+	82	+	88	+
94	+	98	+	101	+
104	+	108	+	112	+
114	+	118	+	127	+
129	+	137	+	30%	

MEBE One Business Center

EVALUATION MATRIX					
5	+	7	+	14	+
19	+	21	+	26	+
31	+	32	+	36	+
39	+	42	+	45	+
48	+	54	+	55	+
56	+	57	+	61	+
66	+	67	+	69	+
70	+	72	+	74	+
79	+	80	+	88	+
94	+	99	+	101	+
105	+	110	+	112	+
114	+	118	+	123	+
137	+	27%			

The facade material is mostly artificial in the form of glass, metal, metal-plastic panels, wood for cladding is rarely used. The scale of the wall covering is usually made of large-element facing material. The surface texture is mostly smooth, matte or glossy. Light color shades combined with dark glazing, less often used bright color accents.

Alternative energy sources are practically not used in Russian examples of environmentally certified buildings. Passive methods of energy saving are also poorly represented. All objects are connected to citywide communications without any consideration *of the life stability of processes* and a closed-autonomous system for the reproduction and utilization of energy, water and waste.

More recent examples of green buildings in Russian cities are beginning to acquire a "life-sustaining" appearance that corresponds to aspects of environmental design and visual ecology. These are flexible spatial planning solutions that interact with the environment and existing context (Table 5).

The percentage of use of ecological architectural and planning solutions in the considered objects increased from 35 to 40%.

When assessing *the influence of climatic parameters*, the uniform ratio of shading zones and lighting on facades is taken into account. In some buildings there is a special plastic volume, provided canopies from the sun. Wind conditions and shape aerodynamics are taken into account. The terrain is organized with the possibility of collecting rainwater. Many sites are characterized by growing green spaces in the surrounding area to reduce the "heat island" and increase biodiversity. The object is *placed in the environment* as part of an ensemble. Often buried volumes are used or raised above the ground. Interaction with the environment occurs due to bionic forms, buffer spaces (terraces, catwalks), the neutrality of the image, taking into account the natural context.

When analyzing *the shape of the object,* a mostly plastic silhouette is selected, with a unexpected distorted scale. Three-dimensional plastic is decorative and symbolic. The metric pattern of volumes is dynamic. At the same time, tectonics are artistic (a plastic form that reflects the fundamental features of the structure) or false (a decorative form that distorts the idea of the load-bearing abilities and stresses of structural elements). The space-planning solution is compact or flattened.

When evaluating the facade plasticity of the analyzed buildings, the roof is plastic curved. The wall surface is structural, structural, or ornamental. Decorative details in the form of geometric or architectural plastic elements. In the color scheme of facades, light tones are mainly used to reduce the heating of surfaces, in combination with solid darkened glazing.

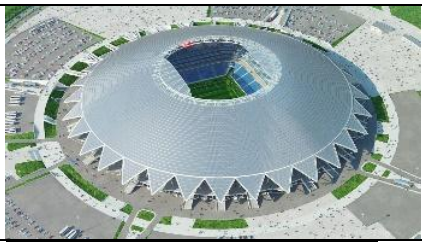
The shape of the plan is round or oval. Construction of wall cladding made of fine - grained cladding material. The texture of the facade walls is rough, grooved, or cellular.

4.3. Typical solutions for environmentally certified facilities

As a result of the analysis of the requirements of certification systems and buildings of different typologies, certified according to international and Russian environmental standards, the following standard solutions for green objects were systematized.

Architectural and planning standard solutions: lack of green spaces on the site; increased surface parking area; large area of hard surfaces in the surrounding area; internal solar protection of premises; possibility of natural ventilation only through window openings; simple cubic volumes; rectangular silhouette; flat roof; functional and structural plastic surfaces; static volume pattern; structural tectonics of the composition; the predominance of a flat monotonous wall surface; simple geometric shapes with minimal use of plastic connections; frame load-bearing frame with a free layout; corridor-ring layout of the plan; rectangular or round plan shape with symmetrical construction; extended horizontal glazing strips on facades; panoramic windows; rhythmic rows of equally repeated window profiles; darkened glass; volume transparency at night; artificial material for finishing facades (glass and metal); smooth surface texture of facing materials; dark-light color scheme (dark glass surface and light facade finishing).

Table 5. Analysis of space-planning features of sports environmentally certified buildings in Russia

Bolshoy Ice Palace, Sochi, 2014 Certificate: BREEAM International Bespoke 2008 – Very Good. The main purpose: a sports complex and an arena for entertainment events. Architects: Tsymbal N., Knyazev A.	Stadium, Samara, 2018 Certificate: BREEAM International Bespoke 2010 – Good. Main purpose: sports complex. Architects: FSUE "Sport-Engineering", Terrniigrazhdanproekt, PSO "Kazan", GMR Architekten.	Volgograd Arena Stadium, Volgograd, 2018. Certificate: BREEAM International Bespoke 2010 – Good. Main purpose: sports complex. Architects: FSUE "Sport-Engineering", Design Institute "Arena".
		

Bolshoy Ice Palace, Sochi:

EVALUATION MATRIX					
1	+	3	+	5	+
7	+	9	+	11	+
14	+	20	+	21	+
24	+	25	+	27	+
28	+	31	+	33	+
37	+	41	+	43	+
47	+	49	+	54	+
55	+	56	+	59	+
61	+	65	+	66	+
67	+	69	+	71	+
74	+	77	+	80	+
84	+	87	+	92	+
98	+	100	+	101	+
104	+	108	+	111	+
114	+	117	+	118	+
121	+	124	+	137	+
36%					

Stadium, Samara:

EVALUATION MATRIX					
1	+	2	+	3	+
4	+	5	+	6	+
7	+	9	+	11	+
14	+	19	+	21	+
24	+	25	+	27	+
28	+	30	+	31	+
33	+	37	+	41	+
43	+	46	+	48	+
54	+	56	+	59	+
60	+	62	+	65	+
66	+	72	+	75	+
78	+	80	+	84	+
90	+	93	+	98	+
101	+	104	+	108	+
111	+	114	+	117	+
120	+	121	+	122	+
125	+	129	+	137	+
38%					

Volgograd Arena Stadium:

EVALUATION MATRIX					
1	+	2	+	3	+
4	+	5	+	6	+
7	+	9	+	11	+
14	+	19	+	21	+
23	+	25	+	26	+
27	+	28	+	29	+
30	+	31	+	33	+
37	+	40	+	43	+
44	+	45	+	48	+
54	+	55	+	56	+
59	+	60	+	62	+
63	+	64	+	65	+
67	+	78	+	80	+
84	+	87	+	92	+
98	+	100	+	101	+
104	+	108	+	112	+
114	+	117	+	121	+
127	+	129	+	137	+
40%					

Engineering and technical standard solutions: management of technological processes during construction and operation; reduction of water consumption due to various devices; irrigation systems for irrigation; energy-efficient structure shell; energy-efficient equipment; control of the indoor microclimate using sensors and regulators; automatic air conditioning system with cooling elements; automation of installations and metering devices across the entire volume; automatic control of ventilation and sun protection (darkening of windows).

Undoubtedly, many of the above measures reduce the "ecological footprint" of the certified object on the planet and help to reduce the pressure on nature.

Only the criteria of green standards do not set rigid boundaries and suggest a creative approach to the implementation of architectural techniques, such as the choice of shape, planning solutions and dimensions.

Other assessment categories impose some restrictions on the freedom of choice, whether it is the creation of a flat operational roof, energy-efficient facades, light colors in decoration, large areas of glazing, types and sizes of windows, efficient equipment, which leads to the replication of eco-friendly buildings with the loss of their individual appearance. An increase in measures to introduce high-tech equipment may negatively affect the formation of certification objects, making them similar to each other.

An overabundance of engineering solutions in environmental standards makes certified buildings dependent on hard-to-renew natural resources. Large-scale use of automated systems requires enormous energy costs, which will not be able to cover only renewable sources (energy from the sun, water, land, etc.).

4.4. Proposal a new Typology of environmentally certified buildings

As a result of the study, functional, spatial-planning, compositional and structural solutions of certification objects are considered. Their main features are graphically systematized.

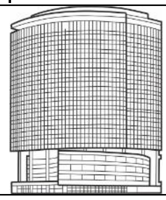
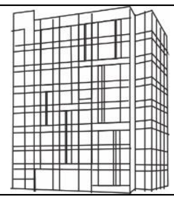
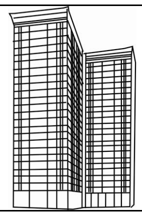
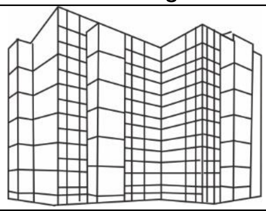
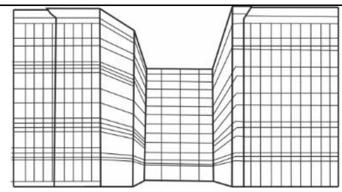
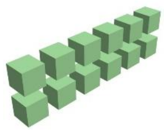
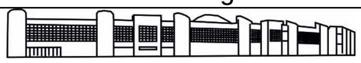
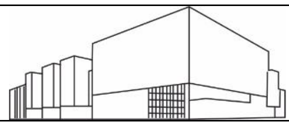
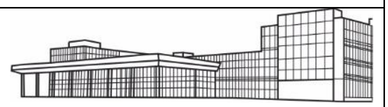
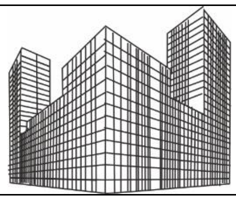
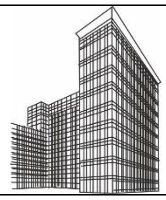
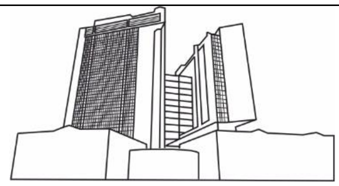
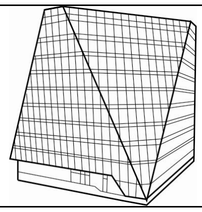
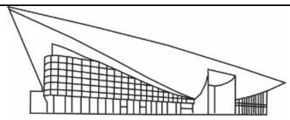
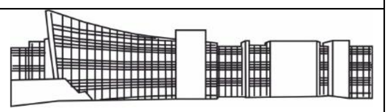
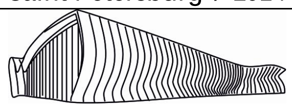
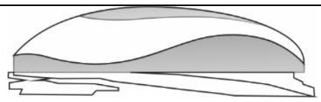
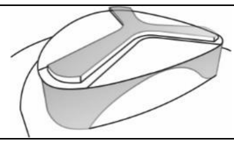
It is revealed that the volume-compositional techniques of certified buildings in Russia according to international and Russian environmental standards have some similar features (Table 6).

It is established that objects located in an urban environment often have a rectangular space-planning solution with a simplified static silhouette that does not argue with urban development. It can also be high-rise dominants or elongated rectangular shapes with typically repeating window openings and geometric elements. Buildings that are oriented to the natural environment do not repeat their solutions, as well as natural components. Smooth curved lines of volumes, deepened rooms, the inclusion of green spaces in the structure of the structure, the use of a green roof contribute to the harmonious fusion of the object with the natural environment.

A new typology of environmentally certified buildings is proposed for the following items:

- *Climate impact:* geometric volumes that do not respond to climate parameters; plastic volumes that respond to climate parameters;
- *Placement in an environment:* map item in an urban environment; object as part of an ensemble; object in a natural environment;
- *Interaction with the environment:* geometric volumes that do not interact with natural components; plastic volumes interacting with natural components; transformable volumes that adapt to natural conditions;
- *Three-dimensional composite solution:* single parallelepipeds of regular shape; paired placement of rectangular volumes; elongated linear volumes; volumes of a plastic silhouette; dynamic volumes with protruding elements; step volumes with complex shapes;
- *Facade plasticity:* volumes with planar facades; volumes with dynamic facades; volumes with a grid structure of facades; volumes with extended horizontal (vertical) profiles on facades; volumes with preservation of the historical appearance of the facades;
- *Layout of the premises:* compact rectangular (square) symmetrical (non-symmetrical) planning solution; compact round (oval) symmetrical (non-symmetrical) planning solution; flattened polygonal non-symmetrical planning solution; sprawling picturesque asymmetrical planning solution;

Table 6. Typological features of certified buildings in Russia

Architectural and compositional features			
Single parallelepipeds of regular shape 			
	Palladium office building / GREEN ZOOM / Yekaterinburg / 2016	Business center "President" / GREEN ZOOM / Yekaterinburg / 2016	Rafinad Minipolis / GREEN ZOOM / Khimki / 2019
Paired placement of rectangular volumes 			
	Development residential complex / GREEN ZOOM / Saint Petersburg / 2017	Grona Lund Residential Complex / GREEN ZOOM / Vsevolzhsk / 2017	Energia Business Center / GREEN ZOOM / Saint Petersburg / 2009
Elongated linear volumes 			
	Khrabrovo Airport / SAR SPZS / Kaliningrad / 2017	Shopping center Kashirskaya / SDR SAR / Moscow / 2018	Diamond Fortune Holdings Note / SDR SAR / Primorsky Krai / 2015
Stepped volumes with a complex silhouette 			
	Lilac Park residential complex / GREEN ZOOM / Moscow / 2019	Serebryany Fontan Residential Complex / GREEN ZOOM / Moscow / 2018	Sberbank Building / SAR SPZS / Moscow / 2018
Dynamic compositions with prominent elements 			
	Class A Business Center / GREEN ZOOM / Saint Petersburg / 2014	Airport Savino / SDF SAR / Perm Krai / 2018	Saint Gobain / SDR SAR / Russia / 2018
Volumes of plastic silhouette 			
	Simferopol Airport / SAR SPZS / Simferopol / 2018	Bolshoy Ice Palace / BREEAM / Sochi / 2012	Sochi 2014 Organizing Committee" / BREEAM / Sochi / 2012

- *Using glazing types:* volumes with panoramic and stained glass windows; volumes with monotonous solid glazing; volumes with extended horizontal glazing strips; volumes with rhythmic rows of rectangular openings;
- *Facade finishing material:* with large-element facade finishing material; with fine-element facade finishing material-element facade finishing material;
- *Use of renewable energy sources:* facilities using renewable energy sources in volume; facilities that do not include renewable energy sources in volume;
- *Object durability (life cycle assessment):* I the object's lifetime (more than 50 years); II the object's lifetime (25-50 years); III object's lifetime (less than 25 years).

5. Conclusions

The orientation of environmental certification systems in construction is studied. The degree of influence of the requirements of environmental standards on architectural design is highlighted.

The share of requirements in environmental standards regarding space-composite and planning solutions, the use of materials, aesthetic and structural solutions, which is on average 30-40% of the total number of requirements for international systems and 20-30% of criteria for Russian environmental standards in construction, is determined.

The analysis of more than eighty Russian green objects using the environmental assessment matrix revealed their characteristic features. The percentage of the use of ecological architectural and planning solutions in the Russian certified buildings under consideration, which is 25-40%, is determined.

Typical architectural-planning and engineering-technical solutions for objects of environmental certification are designated, which create a uniform architectural environment designed "according to a template". An architectural environment that does not correspond to the main aspects of visual ecology without an architectural and expressive image can negatively affect a person's health and well-being.

The necessity of a new approach to the design of environmentally certified objects, with an increase in the role of the architect, in order to avoid simplification and automation of green buildings, is revealed. Environmental measures should be laid by the architect at an early stage of the conceptual solution of the project, in order to reduce operating costs in the future.

A new typology of environmentally certified buildings is proposed according to the following determining factors: climate impact; placement in the environment; interaction with the environment; volume and composition solution; plastic facade; layout of the premises; use of glazing types; finishing material; use of renewable energy sources; the durability of the object.

Due to the lack of a well-formed regulatory framework for environmentally sustainable design, the Russian Federation is just beginning to build its own system of green certification with an integrated approach to the relationship of resource conservation, energy efficiency, environmental safety and comfortable living conditions.

The new emerging architectural space in Russia, taking into account the requirements of sustainable development and green standards in construction, plays an important role in improving the quality of the environment in social, economic and environmental aspects.

It is proved that it is necessary to refine the requirements of Russian environmental standards in construction with an increase in the share of requirements for environmentally friendly architectural and planning and volume-composite solutions (50-70%) and a decrease in the share of engineering and technological measures (20-30%).

Priority areas for the development of environmentally sustainable architectural and urban planning space in Russian cities could be:

- Consideration of climatic features and maximum use of the potential of the construction site (SWOT analysis of the territory, use of renewable energy sources);
- Design in accordance with the principles of bionic and life-resistant architecture (minimum pressure on natural eco-systems, CO2-neutral architecture);
- Resource saving to a greater extent due to the space-planning and compositional solution of the construction object (generative design with a variety of variable solutions);
- User's comfort through a well-thought-out life scenario, eco-modeling of life processes in a residential environment, taking into account design thinking.

According to the identified features of certification and shaping of green buildings, an extensive number of tasks have appeared for further study, which are expected to be solved in further scientific research.

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