Diagnosing the Most Effective Environmental Aspects in Eco-Friendly Multi-Storey Residential Complexes

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Abstract. The global evaluation systems based on the specialized environmental aspects are the most widespread around the world. The ratings of these systems depend on the type of projects to be evaluated and, moreover, on the specifics of the area. In this paper research the author intends to review and analyse the most important terms and indicators of these systems to build the basis for selection and inclusion of the key effective aspects. The purpose of these effective aspects is to improve the environmental performance of eco-friendly residential complexes. The author abstracted and clearly identified six effective environmental aspects furthermore, minor aspects are also implied, and all of them constitute an approved basis for evaluating the performance of environmentally friendly multi-storey residential complexes.

1. Introduction
The energy use has increased in all countries of the world by more than 50% over the last few decades, mainly due to population and economic growth. This increase in non-renewable energy consumption is monetary expensive and it has several negative environmental impacts. The maintenance and operation of buildings are responsible for up to 40% of the total energy consumption globally, and is expected to increase up to 64% by 2100, which will lead to further decrease in averaged life quality in many countries. [1]

It is of global importance to promote interest towards developing the energy-efficient and environmentally friendly construction at all levels.[2] By now many countries have already made energy efficiency strategies a priority in their building regulations.[3]

The standards and rating systems of sustainable buildings evaluation focus on urgent actions to reduce carbon dioxide emissions. It is noted that in order to make the domestic "green standard" popular, a number of measures should be taken to support the innovation and smart environmental solutions. For example, if in some regions of the country with a lack of fresh water priorities for the use of renewable energy sources are provided, then the government will work to support and pay attention to the rational water use indicators, thus, they will be given a greater interest. At the same time, the inadequacy of the basic assessment model is noted, in which the whole technological cycle of energy production is not taken into account in buildings. We think this is the reason why the innovation and smart environmental solutions in environmental aspects should overlap to improve
The ultimate goal of the work is to clearly identify and reconstruct the most optimal environmental aspects for mutual improvement in the multi-storey residential buildings.

2. Materials and methods
The special programs that support "green" technologies, as well as certification systems for the sustainability of buildings were developed. These systems are designed to measure the "green" buildings sustainability level and provide an advanced experiment at the highest certification level.[16][4] [See table 1]

By reviewing and analysing some of the most widely rating systems in the world designed to evaluate and compare the sustainable buildings, we found the most important aspects that provide the psychological and physical comfort for people and give a comprehensive measurable impact on buildings performance. In general, these are either aspects of building environment efficiency or ecological effects on buildings, namely: Management, Health, Energy, Water, Material, Site Quality and landscaping, Pollution, Transport, Land consumption, Ventilation and indoor Comfort, Resources, Innovation, External appearance, Household appliances, Wastes. [See Figure1.]

Using several criteria compiled in guidelines and checklists, building owners and operators can calculate the comprehensive impact on their buildings’ performance. These criteria, taken into account during the planning and construction stages, cover the following: [15-16][4] [See Figure 1.]

- Separate aspects of the building approach to sustainability, like energy efficiency, or
- The whole building approach, like sustainable site development, human and environmental health, water savings, materials selection, indoor environmental quality, social aspects and economical quality.

This research paper deals only with environmental aspects in residential facilities, considering their abilities to influence the quality of economic, social, technical and aesthetic aspects. Therefore, our approach will be a whole-building approach which integrates with other aspects. Thus, we will neglect codes: (E2, E3, E4) in Figure 1.

The two aspects of management (A) and innovation (L) in rating systems for sustainable buildings must be included in all other aspects for the following reasons: [Figure 1]

- The reality of innovation is such that many solutions appear in process, some are direct, some are multi-stage (indirect), some are by trial and error, and some have not yet appeared. Thus, the green building engineering is neither simple nor finite, so the innovation of architectural solutions and designs is in constant correlation with other aspects. [13] [5]
- Adoption of green building is further challenged by the need to provide an integrated construction approach, i.e any particular green innovation requires careful evaluation, integrating multiple innovations increases the number of variables that must be considered and managed. Therefore, environmental management implies the process of planning or the development or forecast of the environmental impact sources existing in the environment surrounding us, and all of them must be linked to all other aspects. [12] [5]

Environmentally friendly dwelling (ECH) means an eco-house designed to be safe for humans and harmless to the environment. Eco-positive living environment is a living environment (housing and surrounding environment) that does not violate the ecological balance, supporting sustainable development, which means that the specific attention is paid to the formation of environmentally friendly houses and settlements. [1] [6]
### Table 1. Comparison of the most widely global rating systems of sustainable buildings evaluation. [15] [4],[56] [7]

| System (Country of origin) & Establishment | Key Aspects of Assessment & Versions | Types of buildings for Assessment | Level of Certification |
|-------------------------------------------|--------------------------------------|----------------------------------|------------------------|
| DGNB (Germany) 2007                       | Ecological Quality (1)               | Offices, Existing Buildings, Retail, Industrial, Portfolios, Schools. | Bronze Silver Gold    |
|                                           | Economical Quality (2)               |                                  |                        |
|                                           | Social Quality (3)                   |                                  |                        |
|                                           | Technical Quality(4) Process Quality (5) Site Quality (6) |                                  |                        |
| BREEAM (Great Britain) 1990               | Management (1) Health & Well-being (2) Energy (3) Water (4) Land consumption (9) | Courts, Eco Homes, Education, Industrial, Healthcare, Multi-Residential, Offices, Prisons, Retail. | Pass Good Very good Excellent Outstanding |
|                                           | Material (5) Site Ecology (6) Pollution (7) Transport (8) |                                  |                        |
| LEED (USA) 1998                          | Sustainable Sites (1) Water Efficiency (2) Energy & Atmosphere (3) | New Construction, Existing Buildings, Commercial Interiors, Core and Shell, Homes, Neighbourhood Development, School, Retail | LEED Certified LEED Silver LEED Gold LEED Platinum |
|                                           | Materials & Resources (4) Indoor Air Quality (5) Innovation & Design (6) |                                  |                        |
| Green Star (Australia) (2003)             | Management (1) Indoor Comfort (2) Energy (3) Land Consumption & Ecology (7) Emissions (8) | Green Star for: Office-Existing Buildings, Office-Interior Design, Office – Design | 4 Stars: ,Best Practice 5 Stars: ,Australian Excellence 6 Stars: ,World Leadership |
|                                           | Transport (4) Water (5) Materials (6) Innovations (9) |                                  |                        |
| CASBEE (Japan) 2001                      | Energy Efficiency (1) Resource Consumption Efficiency (2) Building environment efficiency aspect “BEE=Q/L (Q) (Ecological Quality of buildings) Q1 - Interior space, Q2 – Operation, Q3- Environment (L) Loadings (Ecological effects on buildings) L1 – Energy, L2 – Resources, L3 - Material | Building standards are available: (1) Minergie (2) Minergie-P additional criteria to (1): (3) Minergie-Eco additional criteria to (1): (4) Minergie-P-Eco | C (poor) B B+ A S (excellent) |
| Minergie (Switzerland) 1998              | Dense building envelope (1) Efficient heating system (2) Comfort ventilation (3) Airtightness of building envelope (4) Efficiency of household appliances (5) Healthy ecological manner of construction (optimized daylight conditions, low emissions of noise and pollutants) (6) Adherence to criteria of Minergie-P and Minergie-Eco | Building standards are available: (1) Minergie (2) Minergie-P additional criteria to (1): (3) Minergie-Eco additional criteria to (1): (4) Minergie-P-Eco | Minergie Minergie-P Minergie-Eco Minergie-P-Eco |
| RGBS (Russia) 2010                        | Environmental management (1) Site selection, infrastructure and landscaping (2) Architectural planning and design solutions (3) Rational water use, storm water management and pollution prevention (4) Energy saving and energy efficiency (5) Materials and wastes (6) Quality and comfort of the living environment (7) Life safety (8) |                                  | Plain Silver Gold Platinum |
That is mean the eco-friendly architectural form of the multi-storey residential complex in a simple structure is a cottage with several different levels above ground. [71] [8]

The distinguishing features of the Eco-house are: [71][8]
- Effective thermal insulation;
- Use of solar energy and other natural resources;
- Autonomous power supply systems;
- High-quality treatment and recycling of household waste;
- Natural, environmentally friendly construction and finishing materials.

With the concept of material recycling and its link with waste treatment, two important aspects can be abstracted from features mentioned below: innovation in energy management(C), (F5) and innovation in materials management (E). [Figure 1]

![Figure 1](image_url)

**Figure 1.** Comparison of different sustainable buildings rating systems by their major indicators with codes based on building environment efficiency aspects or ecological effects on buildings.

It is possible to save water effectively and use water reuse systems that could bring financial benefits for the residents of the multi-storey buildings through the effectiveness of demand-side and supply-side water conservation measures and identify viable solutions to reduce domestic water consumption. [9] On the other hand, adoption of effective passive design strategies for space heating...
and cooling, rather than sole reliance on air conditioners, offers significant potential for energy conservation in multi-storey buildings, especially in highly energy-intensive ones. Effective provision of natural ventilation in the multi-storey buildings can save both energy and money compared to mechanical ventilation.[183][3]

So the basic environmental aspects abstracted from the point mentioned above are: innovation in water-saving management (D) and innovation in indoor atmosphere management (J). [See Schema (1)]

The development of architectural forms by increasing the building height is spatially and structurally more complex but it will become easier with the active use of environmental, resource and energy-saving technologies and other architectural solutions. [p.70] [8]

On the psychological level, residents of a multi-storey residential building can be influenced by the height of the apartment and the level of premises location. For example, many people have a psychophysiological effect of an uncomfortable state at the elevation above 30 m from the ground floor. Also, there is a feeling of oppression by the external environment. [P.379][10]

Therefore, the importance of the ideal usage of the land and landscaping site appear to be of great importance in improving the psychological aspects, also one of the main directions of improving the quality of the architecture of multi-storey residential complexes is the individualization and originality of the appearance, increasing the aesthetic expressiveness of the facades.[11]

Thus, environmental aspects that can be abstracted from the last point mentioned are: an innovation in site planning management (F) and innovation in building appearance management (M). [Figure 1]

![Figure 2. Major and minor environmental aspects and aspects abstracted from the most widely rating systems in the world to evaluate sustainable & friendly residential complexes.](image-url)
3. Conclusions
Accordingly, we can conclude that list of major environmental aspects, which improve the environmental performance of environmentally friendly multi-storey residential complexes are:

[Figure 2]
1. Innovation in energy management;
2. Innovation in materials management;
3. Innovation in water-saving management;
4. Innovation in ventilation and indoor atmosphere management;
5. Innovation in Site Planning management;
6. Innovation in building appearance management

The other aspects in different rating systems for sustainable buildings in the table 1. or others, which are represent building environment efficiency aspects or ecological effects on buildings, we can add them in the list special environmental aspects, which must be distributed within basic aspects.

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