UDK 711; 712; 72.01; 721

Tetiana Pavlenko[1], Iryna Ryzhova[2], Tetyana Lytvynenko[3], Oleksandr Zubrychev[4], Svitlana Zakharova[5]

[1]Ph.D, Associate Professor, Head of the Department of Design
National University «Zaporizhzhia Polytechnic»
tanya.mukha.85@gmail.com
orcid.org/0000-0001-8374-554X
[2]Doctor of Philosophy, Professor, Professor of the Department of Design
National University «Zaporizhzhia Polytechnic»
17design2017@gmail.com
orcid.org/0000-0002-9562-200X
[3]Candidate of Technical Sciences, Professor, Professor of the Department of Highways, Geodesy and Land Management
National University «Yu. Kondratyuk Poltava Polytechnic»
litta2510@gmail.com
orcid.org/0000-0002-7229-201X
[4]Ph.D, Associate Professor, Associate Professor of the Department of Design
National University «Zaporizhzhia Polytechnic»
woodlook92@ukr.net
orcid.org/0000-0002-0948-7033
[5]Candidate of Philosophical Sciences, Associate Professor of the Department of Design
National University «Zaporizhzhia Polytechnic»
arconzp@meta.ua
orcid.org/0000-0002-6952-2558

THE MAIN CRITERIA FOR EVALUATING URBAN AREAS AS BARRIER-FREE ECO-CITIES

https://doi.org/10.32347/2519-8661.2025.33.228-240

Abstract. The article defines the main issues and prospects for the development of the eco-city concept in terms of sustainable development. In the process of identifying the main issues, the relevance of the research was determined, which consists in identifying the main directions of urban development of the eco-city for further research on the characteristics of each. Having conducted a thorough analysis of the existing state of the formation of eco-cities in conditions of sustainable development, it was found that their development is multi-vector and includes spatial, energy-efficient, ecological and economic aspects with minimal impact on the environment. The main trends in the development of eco-cities were identified, which made it possible to determine their role in the formation of a modern urban environment in terms of increasing the energy efficiency of buildings, barrier-free environment, the use of alternative energy, "green" technologies and the

latest materials. Based on the conducted research, the main directions of the spatial development of the eco-city were determined: new approaches to zoning territories, ecological construction and energy saving, creation of a barrier-free environment, use of alternative energy sources and ecological infrastructure, eco-transport, waste disposal.

Keywords: barrier-free, inclusion, universal design, eco-city, sustainable development, ecological technologies, urban areas.

Introduction. In the latter half of the last century, a new trend emerged in the global practice of urban development: the construction of eco-cities. This trend has since evolved into a distinct strategy for urban development. A modern eco-city is a substantial settlement (potentially on its way to becoming a metropolis) in which urban activities exert minimal impact on the surrounding environment, avoiding air and water pollution and having no adverse effects on the flora and fauna within and around the city.

The reconstruction period following the two World Wars led to significant social changes. The rapid population growth of the 1950s resulted in mass migration and urbanization. Advances in technology and medicine increased life expectancy and allowed people with disabilities to live longer and more fulfilling lives.

There is a need to identify the main directions of urban development for eco-cities to further investigate the specific characteristics of each.

The primary aim of this study is to identify the main directions of urban development for eco-cities to facilitate a deeper understanding of their unique features.

Literature Review. The concept of «sustainable development» and energy efficiency in the architecture of eco-cities have been extensively examined by international scholars, including D.H. Bay, N. Baker, K. Braizer, D. Valler, S. Guy, P. Gevorkian, L. Glicksman, P. Davy, S. Zokoley, D. Lynn, F. Mounsell, B.L. Ong, P. Smith, D. Williams, and L. Heiselbach. Among domestic researchers, the notions of «sustainable development» of eco-cities and energy efficiency in architecture have been studied by O.B. Borysenko, A.A. Dolinsky [2], L.M. Vilinska [1], O.I. Filonenko, O.I. Yurin, N.M. Magas, V.V. Rudenko, P.O. Semko [7], and G.G. Farenyuk [6]. K.Y. Sikora and O.M. Nazarenko [5] explored solar architecture as an alternative to prevent greenhouse gas emissions.

Issues of effective transport organization are being investigated based on the latest technologies [9, 11, 12, 13, 29, 43].

Active research is being conducted on the creation of barrier-free and inclusive environments in most developed countries [3, 16, 25, 35].

Materials and methods. In conducting this research, the authors employed the following methodological toolkit: theoretical methods of abstraction were used to select the primary research analogs, generalization was applied in forming the main description of the historical experience related to the subject of the study, formalization was used to determine the specific features of examples, comparison was utilized to establish and identify key patterns, and analysis and synthesis were applied to the obtained results to formulate the research conclusions and to underscore the necessity for further scientific development in the presented topic.

Results and discussion. The term "ecocity" was first introduced by American builder and environmentalist Richard Register in 1987 [2]. Register defined an ecocity primarily as an environmentally clean city. His concepts of an ecocity exemplified a comprehensive approach to environmental protection, advocating for minimal consumption of natural resources and maximum independence from mineral resources or hydrocarbons through the use of renewable energy sources.

Today, Register's definition of an ***ecocity*** has been widely embraced and is used to describe a sustainable urban settlement capable of self-sufficiency in terms of resources, with minimal urbanized areas.

In 1987, the United Nations' "Sustainable City" concept outlined a city that rationally uses environmental resource reserves, allowing them to regenerate and preventing their depletion, while also maintaining acceptable levels of environmental impact from harmful factors.

The "Global Forum-94" saw the presentation of the first real-world ecocity project in Sweden, created in accordance with the principles of sustainable development. In the early 21st century, the "Habitat-II" global forum adopted the concept of creating ecocities.

The development of ecological settlements, initiated by Paolo Soleri, reached a new level in this century. Soleri's new city development concept, "Solare: the Lean Linear City," proposed in 2005, envisions a small city with a controlled climate. The architectural firm led by Norman Foster has developed several innovative eco-urbanistic solutions. An example of sustainable development is the ecocity in Incheon (2009), which has become a hub for technological "green architecture" in South Korea. Another notable project is the Masdar City in Abu Dhabi (2008), a groundbreaking development aiming for zero emissions. Masdar City promises to embody green technologies and alternative energy, with plans for the largest solar power plant in the Middle East and the complete elimination of internal combustion vehicles, thereby achieving zero carbon dioxide emissions [7].

Currently, in the European Union, there are six ecocities: Malmo (Sweden), Dublin (Ireland), Tallinn (Estonia), Hillerod (Denmark), Hamburg (Germany), and Augustenborg (Denmark). In Europe, the environmental issues of urban areas have long been a cause for concern, and due to the high population density, the need for ecological reconstruction of residential buildings has become increasingly pressing. Projects for the reclamation of industrial areas are gaining popularity. The experience of England in reconstructing industrial zones highlights several key trends: the reclamation of central industrial areas for housing, office buildings, and public recreational facilities.

The experience of the United Arab Emirates in urbanizing the desert shows a trend towards the design and implementation of eco-technological solutions. Masdar City (Abu Dhabi) is a pioneering green city project with zero carbon emissions and alternative energy sources. The city was designed by the British architectural firm «Foster + Partners». The project is being implemented in waves and is still ongoing. The authors of the project embody the idea of comfort for pedestrians and cyclists with an innovative city navigation system and architectural-urban solutions to bring cool air into the city space in a desert hot environment. They have reduced direct sunlight by densifying and raising the construction above ground level (a city on stilts).

Thanks to the warm climate, most of the energy is produced at solar power plants, and the roofs of buildings are equipped with photovoltaic generators. A crucial criterion for the city's functioning is the absence of emissions and waste. The «Foster + Partners» project proposes a city without conventional cars, featuring driverless electric shuttles, creating a comfortable microclimate through advanced technologies.

The high-speed public transportation system is designed as the primary urban communication network, integrating the requirements of private transport and the ecological considerations of the project. In Masdar, wastewater is repurposed for irrigation. Water and energy resources are monitored and managed by an electronic artificial intelligence system to minimize consumption. Masdar City is a significant ecological initiative and a benchmark for sustainable urban development.

A prime example of a comprehensive ecocity, embodying the principles of social and architectural ecology, is Malmo. The city's redevelopment initiated with its districts, specifically focusing on the western district, which is designed to be entirely self-sufficient in its energy needs through the use of alternative sources. Solar panels are extensively utilized in Malmo. Solar energy is harnessed to fulfill the electricity and water heating requirements within the water supply and heating systems. Thus, the number of solar panels installed on buildings is calculated based on the individual building's energy needs, predominantly on public

buildings due to this requirement. Such installations typically have a guaranteed lifespan of 25 years, with photovoltaic systems expected to last around 50 years.

Reducing the negative impact on the environment is one of the priority tasks in transforming Malmo into an ecocity. The means to achieve this goal include new construction technologies, improved transportation systems, the use of alternative energy sources, and energy-saving technologies. Currently, Malmo is the third largest industrial city in Sweden. Consequently, it was decided to use only renewable energy sources (solar panels, wind turbines, heat pumps, biogas) for electricity production, heating, and vehicle fuel.

In China, the issues of overpopulation and environmental degradation due to extensive industrial activities are particularly pressing. Rivers, air, and soil are heavily polluted, prompting the government to engage environmental engineers in developing solutions. One such initiative is Great City, a planned urban area on the outskirts of the Chengdu metropolis, aimed at achieving energy efficiency and ecological preservation.

A key feature of the Chengdu Great City project is the incorporation of a "vertical forest" designed to maintain a zero-carbon balance through extensive vegetation. The Qiyi City Forest Garden project in Chengdu exemplifies this concept by integrating vertical greenery with plants on every balcony.

China's ambition extends to constructing an eco-city where transportation operates on biofuels, and electricity is derived from solar and wind energy. This new urban development is named Dongtan. The Dongtan city project was showcased at the World Urban Forum by the United Nations (UN) in China as an exemplar of an eco-city. All buildings in Dongtan are planned to be highly energy-efficient. Additionally, a network of high-tech farms will be established at the city's periphery to filter air and remove CO2 emissions.

The buildings in the city will be constructed with natural ventilation, thus requiring less energy. Additionally, green roofs will enhance insulation and water filtration. Developers aim for the city to eventually become zero-waste, producing its own electricity and thermal energy. Buildings and transportation will operate on renewable energy sources, such as wind farms, building-mounted turbines, and solar panels. Combined heat and power generation will be conducted at facilities using waste from rice mills. Solid waste and wastewater treatment will produce methane and other energy sources.

Dongtan will feature a compact layout in three settlements surrounding the commercial center, minimizing the need for car use within the city. All residences will be designed and built within a seven-minute walk of public transport stops. Businesses, schools, hospitals, and other facilities will be easily accessible.

Movement within the city will be possible via bicycles, walking, and vehicles using hydrogen fuel cells, solar-powered buses, and water taxis. Boats will navigate a network of canals and lakes. These energy-efficient transportation modes will emit virtually no greenhouse gases. The project is slated for completion by 2050.

One of the core concepts underpinning the design of eco-cities is the principle of universal design, which emerged in the latter half of the 20th century to address the creation of spaces that cater to everyone.

Universal design is exceptionally flexible, as it does not entail creating additional conveniences for specific groups of people. Instead, it focuses on finding adaptable solutions for everyone.

Ronald Mace is the originator of the concept of universal design, which involves creating residential and public spaces that are comfortable to use regardless of age or health status. He played a significant role in legislative changes in the United States, where the principles of building accessibility were established for the first time in the country’s history.

In 1989, Mace founded the Center for Accessible Housing (now the Center for Universal Design) and developed seven principles of universal design [26]:

- **Equitable use**: The design is useful and marketable to people with diverse abilities, ensuring appropriate and identical use for individuals with varying capabilities, language proficiencies, and skills.

- **Flexibility in use**: The design accommodates a wide range of individual preferences and abilities, adapting to both right- and left-handed users, varying user speeds, and formats of sound and video.
- **Simple and intuitive use**: The design is easy to understand, regardless of the user's experience, knowledge, or language skills, making the design straightforward for everyone.
- **Perceptible information**: The design communicates necessary information effectively to the user, regardless of ambient conditions or the user's sensory abilities, including those with hearing impairments or non-native speakers.
- **Tolerance for error**: The design minimizes hazards and the adverse consequences of accidental or unintended actions, reducing risks associated with user errors.
- **Low physical effort**: The design can be used efficiently and comfortably with minimal fatigue, ensuring ease of use with minimal exertion.
- **Size and space for approach and use**: Appropriate size and space are provided for approach, reach, manipulation, and use, regardless of the user's body size, posture, or mobility, ensuring physical accessibility in all situations.

The level of inclusivity in a city also encompasses economic opportunities for immigrants, preservation of diversity, and integration into the community. This inclusivity is determined by various factors, including the organization of residential and public spaces.

Among the most inclusive cities in Europe, London, Rotterdam, and Berlin are at the forefront.

In preparation for the 2012 Summer Olympics and Paralympics, London focused on inclusivity and universal design principles. These principles were primarily applied in public transportation, establishing London as one of the most accessible cities for travelers with diverse needs.

Since 1992, Berlin has implemented a policy of planning barrier-free and convenient spaces, starting with pedestrian crossings and extending to the creation of modern transport infrastructure and accessible public areas. A notable example of the implementation of universal design principles is the Berlin Hauptbahnhof, regarded as the largest and most modern railway station in Europe.

Rotterdam stands out as a city designed for the well-being of its residents, where accessibility and inclusion are central and integrated into urban planning policies at all levels. In 2014, fundamental principles for creating public spaces in the city were developed, along with revisions to road design regulations. Additionally, a special program was implemented to identify and address accessibility issues in public spaces. In 2016, Lonely Planet named Rotterdam the best city for tourism. In 2017, it secured second place in the Access City Award competition among Europe's most accessible cities.

Globally, there are leading companies in eco-city development that set the standards others follow. Ukraine currently lacks such companies. However, a unique concept for an eco-city has been developed in Odessa. The designated area for this project is unparalleled in any country, due to its excellent location near the historic center, which is of interest to UNESCO for its unique architecture, the grandeur of the concept, the natural resources available, and the project's overall scale.

The concept of the first Ukrainian eco-city significantly surpasses the most impressive current development project, Dubailand (200 km²), which features the largest entertainment and sports complex of international class in the Middle East. The designated area for the eco-city stretches from the Peresyp Bridge to Kryzhanivka, from the sea to the inter-lake region.

This area of Odessa once had significant resource potential, including archaeological sites, a nature reserve, unique flora and fauna, the waters of the Kuyalnik estuary, and a comfortable climate. Currently, numerous design solutions for the eco-city are under review and approval, which could address Odessa's major issues. One notable plan is to build a modern technopolis – the Khadzhibey complex, an equivalent to Silicon Valley, featuring high-tech and environmentally friendly industries. The primary idea of this project is to create

comfortable working conditions, thus the complex is designed for family living and will include necessary infrastructure and recreational facilities.

In Odessa, there is significant interest in relocating many existing facilities to the eco-city area and developing entirely new, state-of-the-art infrastructure that meets international standards. The «green construction» initiatives within Odessa's eco-city aim to address critical urban challenges at the highest level. This includes resolving the problematic transportation routes between Kotovsky village and other parts of the city, restoring the coastal maritime routes with sea trams, and implementing projects that establish new urban energy-generating facilities utilizing wastewater treatment plants. These facilities will be integrated into a closed ecosystem for the production of biogas and biofuels. Additionally, the plan includes constructing a reversible hydroelectric power plant on the «Hadzhibey-Sea» canal. The first large-scale «green construction» project in Ukraine is still in the planning stages.

Ukraine is actively advancing towards creating more accessible cities. Terminal D at Boryspil International Airport is a prime example of this progress. Boryspil Airport is considered the only Ukrainian airport that meets all international standards for accessible service across various passenger types.

Meeting the needs of the population and creating genuinely accessible public spaces and inclusive cities is a priority for many countries worldwide.

Key criteria for evaluating urban areas as barrier-free eco-cities

Based on contemporary concepts of societal development and the enhancement of architectural and urban planning principles, particularly in the design of eco-cities, it is proposed to incorporate the principle of inclusivity into the core concepts of green architecture.

Inclusivity is fundamental to accessibility. It is an active process that increases the level of participation of the entire population in societal life, ensuring barrier-free environments and the development and implementation of solutions that allow full participation in public life.

Inclusivity has become a significant theme across various fields, facilitating broader creation of conditions and spaces that enable comprehensive participation in life. Therefore, research on these issues is highly relevant [14].

Several key criteria for evaluating urbanized areas (Fig. 1) have been identified, which, according to the authors, can classify a settlement as a barrier-free «eco-city»:

1. *Inclusivity and barrier-free access:* Creating accessible residential and public spaces regardless of gender, health status, age, etc.
2. *Ecological construction and energy efficiency:* Ecological or «green» building standards have been in global construction practice for over 20 years. The economic advantages of green building include:
   - Reducing energy consumption
   - Decreasing water usage
   - Lowering building maintenance costs

   Urban energy efficiency is achieved through:
   - Designing and constructing buildings with architectural and structural solutions that ensure long and efficient lifespans
   - Employing a range of modern technical developments aimed at obtaining and conserving various types of energy and their efficient application, as well as integrating these developments into construction practices

For assessing the ecological and energy efficiency of buildings, environmental certification is widely used, developed by many countries. The most common are the American LEED and British BREEAM certifications. Evaluating a building's ecological efficiency supports the design of methods and techniques for conserving the natural environment.

№	TITLE	DESCRIPTION	IMAGE
1	INCLUSIVITY AND ACCESSIBILITY	Creating residential and public spaces that are convenient for use regardless of age, gender, or health status.	
2	ECO-FRIENDLY CONSTRUCTION AND ENERGY CONSERVATION	Ecological standards: a) Reducing energy consumption; b) Reducing water usage; c) Reducing building maintenance costs.	
3	USE OF ALTERNATIVE ENERGY SOURCES	Primarily utilizing renewable energy sources in eco-cities: wind turbines, solar panels, biogas from wastewater.	
4	ECO-TRANSPORTATION	Eco-transport includes all means of transportation that are least harmful to nature and human health (electric, hydrogen, biofuel, bicycles, and certain types of public transport).	
5	WASTE MANAGEMENT	An eco-friendly lifestyle involves the effective disposal of human activity waste.	
6	CREATION OF ECOLOGICAL INFRASTRUCTURE	Ecological infrastructure is a complex of interacting natural, semi-natural, and artificial objects and systems that ensure the preservation of the living environment.	
7	INFORMATION AND SAFETY	Ensuring safe use of spaces with adequate information	

Figure 1. *Main criteria for evaluating urbanized areas as barrier-free eco-cities*

Source: developed by the authors based on analyzed analogs

3. *Utilization of renewable energy sources*. This includes the implementation of solar panels, wind turbines, biogas systems, and other renewable energy technologies.

4. *Eco-friendly transportation*. Eco-friendly transportation refers to all means of transport that are least harmful to nature and human health. The main types include electric vehicles, hydrogen-powered vehicles, biofuel-powered vehicles, bicycles, and certain types of public transportation (subways, electric trains, monorail systems, water taxis, etc.).

5. *Waste management*. An eco-friendly lifestyle involves the efficient disposal of human-generated waste. This is not only pertinent to eco-cities but is also a focal point of environmental programs in many large cities. Key aspects include effective waste collection, disposal, and recycling, with a strong emphasis on segregating waste at the source to facilitate recycling processes.

6. *Development of ecological infrastructure*. Ecological infrastructure encompasses a complex of interacting natural, semi-natural, and artificial objects and systems that ensure the preservation of human living environments.

7. *Information and safety*. Ensuring the safe use of urban spaces through adequate artificial lighting, inclusive transportation options, road safety measures, and secure navigation of height differences. Additionally, providing comprehensive information systems (clear navigation, information about potential obstacles, technical aids for traffic organization, etc.) is essential.

Ecological infrastructure in eco-cities primarily includes natural environment zones within the city (parks, recreational areas, natural landscape zones along city streets, etc.) as well as agricultural zones. These zones can exist both within the city limits (e.g., vertical farming buildings or «agro-skyscrapers») and in adjacent areas to the urban settlement zone.

Conclusions. To improve urban areas and create barrier-free eco-cities, the following key recommendations should be followed:

1. Adherence to principles of inclusivity and barrier-free design.

2. Ensuring adequate informational and environmental safety conditions within urban areas.

3. Utilization of eco-friendly materials to reduce the environmental footprint of products.

4. Adoption of ecological production processes to minimize negative impacts on the environment.

5. Maximizing the efficiency of resource utilization by considering the entire product lifecycle from creation to disposal.

6. High-quality product design to extend lifespan, minimize repairs, and ensure mandatory recycling.

In conclusion, the creation of ecologically and inclusively favourable conditions in urban areas is a complex process that requires further research, the development of pilot projects, and experimental construction.

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Павленко Т. О.[1], Рижова І. С. [2], Литвиненко Т. П. [3], Зубричев О. С. [4], Захарова С. О. [5]

[1]кандидат архітектури, доцент, завідувач кафедри дизайну
Національний університет «Запорізька політехніка»
tanya.mukha.85@gmail.com
orcid.org/0000-0001-8374-554X

[2]доктор філософських наук, професор, професор кафедри дизайну
Національний університет «Запорізька політехніка»
17design2017@gmail.com
orcid.org/0000-0002-9562-200X

[3]кандидат технічних наук, професор, професор кафедри автомобільних доріг, геодезії та землеустрою
Національний університет «Полтавська політехніка імені Юрія Кондратюка»
litta2510@gmail.com
orcid.org/0000-0002-7229-201X

[4]кандидат архітектури, доцент, доцент кафедри дизайну
Національний університет «Запорізька політехніка»
woodlook92@ukr.net
orcid.org/0000-0002-0948-7033

[5]кандидат філософських наук, доцент кафедри дизайну
Національний університет «Запорізька політехніка»
arconzp@meta.ua
orcid.org/0000-0002-6952-2558

ОСНОВНІ КРИТЕРІЇ ОЦІНКИ УРБАНІЗОВАНИХ ТЕРИТОРІЙ ЯК БЕЗБАР'ЄРНИХ ЕКО-МІСТ

Анотація. В статті визначено основну проблематику та перспективу розвитку концепції еко-міста в умовах сталого розвитку. У процесі виявлення основної проблематики визначено актуальність

дослідження, яка полягає у виявленні основних напрямків міського розвитку еко-міста для подальшого дослідження особливостей кожного. Провівши ґрунтовний аналіз існуючого стану формування еко-міст в умовах сталого розвитку, виявлено, що їх розвиток багатовекторний та включає просторові, енергоефективні, екологічні та економічні аспекти при мінімальному впливі на довкілля. Виявлені основні тенденції розвитку еко-міст, які дали можливість визначити їх роль у формуванні сучасного урбанізованого середовища у аспектах підвищення енергоефективності будівель, безбар'єрності середовища, використання альтернативної енергії, «зелених» технологій та новітніх матеріалів. На основі проведеного дослідження визначені основні напрямки просторового розвитку еко-міста: нові підходи до зонінгу територій, екологічне будівництво та енергозбереження, створення безбар'єрності середовища, застосування альтернативних джерел енергії та екологічної інфраструктури, екотранспорт, утилізація відходів.

Ключові слова: безбар’єрність, інклюзія, універсальний дизайн, еко-місто, сталий розвиток, екологічні технології, урбанізовані території.