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METHODOLOGICAL BASES FOR THE SUSTAINABLE DEVELOPMENT OF UNDERGROUND INFRASTRUCTURE FACILITIES IN UKRAINE: PROBLEMS AND PROSPECTS

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МЕТОДОЛОГІЧНІ ОСНОВИ СТАЛОГО РОЗВИТКУ ПІДЗЕМНИХ ІНФРАСТРУКТУРНИХ ОБ'ЄКТІВ В УКРАЇНІ: ПРОБЛЕМИ І ПЕРСПЕКТИВИ

The objective of this paper is to create methodological bases for the sustainable development of underground infrastructure projects with account of certain factors to substantiate elasticity and stability, when conducting technological processes on the underground space development. The analysis of modern methods and tooling for the formation of the urban designing system with the implementation of mixed-use schemes in Ukraine, made it possible to determine that the project financing is a promising form of the capital investment into the most profitable sectors of the state economy or into private business. The analysis of modern methods of planning and designing of urban infrastructure systems has made it possible to substantiate the promising directions for development of the underground space use with application of the innovation model of sustainable development through the implementation of designated programs of high-tech modernization and renovation of the economic complex. Based on the analysis of modern planning methods for infrastructure facilities, an innovation system of the country is proposed, which is being formed by stages in order to create sustainable urban designing with the implementation of mixed-use schemes with a high density in Ukraine, and with subsequent steady functioning of this infrastructure. The practical relevance is in the definition of universal innovation policy, as a combination of basic principles and directions for creating the effective state mechanisms of market relations, as follows: formation of the regulatory and legal framework in the field of innovation activity; ensuring the interaction between science, education, production, financial and credit sphere in the development of innovation activities; technology transfer and financial support. The scheme for the regulatory innovation mode has been substantiated by means of which the economic growth in the country is stimulated within the framework of the appropriate established system of incentives and constraints.

The high requirements for reliability, durability and safety of underground infrastructure facilities (UIF) predetermine the necessity to develop a reliable geomechanical interaction support of an underground structure or an underground part of an infrastructure facility with an enclosing massif. This requirement is an essential element in the process of designing, construction and operation of the UIF, and the large-scale goals facing the underground complexes show its necessity and expediency.

Метою роботи є створення методологічних основ сталого розвитку підземних інфраструктурних проектів з урахуванням певних чинників обгрунтування еластичності та стійкості при проведенні технологічних процесів на підземному освоєнні простору. Аналіз сучасних методів та інструментів формування системи містобудування з впровадженням схем багатоцільового використання в Україні дозволив визначити, що проектне фінансування є перспективною формою капітальних інвестицій у найбільш прибуткові сектори України, економіку держави або приватний бізнес. Аналіз сучасних методів планування та проектування систем міської інфраструктури дозволив обгрунтувати перспективні напрями розвитку використання підземного простору із застосуванням інноваційної моделі сталого розвитку шляхом реалізації визначених програм модернізації високотехнологічного і оновленого господарського комплексу. На основі аналізу сучасних методів планування об'єктів інфраструктури пропонується інноваційна система країни, яка формується поетапно з метою створення стійкого містобудування з впровадженням схем змішаного використання з високою щільністю в Україні, та з подальшим стійким функціонуванням цієї інфраструктури. Практична актуальність полягає у визначенні універсальної інноваційної політики, як сукупність основних принципів та напрямів створення ефективних державних механізмів ринкових відносин: формування нормативно-правової бази у сфері інноваційної діяльності; забезпечення взаємодії науки, освіти, виробничої, фінансово-кредитної сфери у розвитку інноваційної діяльності; передачі технологій та фінансової підтримки. Обгрунтовано схему регуляторного інноваційного режиму, за допомогою якої економічне зростання в країні стимулюється в рамках відповідно встановленої системи стимулів і обмежень.

Високі вимоги до надійності, довговічності та безпеки підземних об'єктів інфраструктури (ПІО) зумовлюють необхідність розробки надійного геомеханічного взаємодії підземного споруди або підземної частини об'єкта інфраструктури з огороджуючим масивом. Ця вимога є суттєвим елементом у процесі проектування, будівництва та експлуатації ПІО, а масштабні цілі, що стоять перед підземними комплексами, свідчать про його необхідність і доцільність.

Key words: underground infrastructure facilities, innovation policy, sustainable urban design of infrastructure systems, "sustainability" and "elasticity" of long-term design solutions.

Ключові слова: підземні інфраструктурні об'єкти, інноваційна політика, стале міське проектування інфраструктурних систем, "стійкість" і "пружність" довгострокових проектних рішень.

FORMULATION OF THE PROBLEM

The infrastructure and institutional foundation governing the business investment into the large-scale infrastructure projects are essential elements of the investment attractiveness of any country. At the same time the necessity arises to develop and substantiate these projects for major cities of Ukraine, taking into account the rational use of underground space, the existing volumes of ground water and military operations in the country, which cause a threat to the economic, technical, technological and information security of the country. When planning such projects, it is also reasonable to take into account the architectural integrity of cities.

ANALYSIS OF RECENT STUDIES AND PUBLICATIONS

Underground Infrastructure Facilities (UIF) function as a dynamic terminal through which the geotechnical systems and ecosystems interact and influence each other. Accounting for the impact of this mutual dependency is important for assessing the stability of infrastructure projects, since this is the basis for decision-making in the implementation of civil construction.

The mining industry has an extensive experience in the construction and long-term usage of underground space. One of the factors that put the brakes on the widespread development of the underground urban space is the lack of reliability in structural supports of underground structures. In spite of the great achievements in the designing and construction technology of such facilities, they do not always meet the requirements of long-term usage [1].

The world experience of progress in advanced countries and companies shows that their success is based on the application of an innovation model of sustainable development through the implementation of designated programs of high-tech modernization and renovation of the economic complex. Therewith, the highest indicators of quality, timeliness and efficiency of implementation of construction investment projects and programs for the development of industrial systems in the USA, Japan, Russia and the EU countries are today achieved through the use of project management, engineering and project financing. Their use as compared to methods of organization and management of the complex objects construction, traditional for the Ukrainian economy, makes it possible to reduce labour costs and the project duration by 10—20%, and the total cost by 8—15% [3].

African scientist Thabang Mokoaleli-Mokoteli devoted his research to the protection of investors and the removal of danger for them [4]. This will enable the Ukrainian audit firms to provide their services to African businesses; Olaumi D. Avolusi, in his research, was looking for the influence of foreign direct investment on the development of African countries [5]; R. Safarov, A. Panischev engaged into numerous modelling investment of risks.

The well-known domestic and foreign scientists K.A. Bardyish [6], P.P. Batenko, P.N. Zavlin, A.V. Onishchenko [7], D.K. Pinto [8], M.L. Raza [9], R.B. Tyan [10], V.D. Shapiro and others, studied the issues of organization and management of projects in the field of construction.

SETTING OBJECTIVES

Analysis of the formation strategy of underground infrastructure facilities in Ukraine and the formation of institutional conditions for the formation underground infrastructure facilities (UIF)

CONTRIBUTION OF THE MAIN MATERIAL

The high requirements for reliability, durability and safety of underground infrastructure facilities (UIF) predetermine the necessity to develop a reliable geomechanical interaction support of an underground structure or an underground part of an infrastructure facility with an enclosing massif. This requirement is an

essential element in the process of designing, construction and operation of the UIF, and the large-scale goals facing the underground complexes show its necessity and expediency.

The geomechanical supporting of the UIF on the territory under consideration solves the following tasks: creation of the long-term (for a calculated period) stability of underground facilities, geomechanical control over the stress-strain state of the host rocks; determination of the underground facility influence on the environment and engineering structures, both during construction and operation, as well as in the period of reconstruction and especially liquidation. The main purpose of the geomechanical support of the UIF is to prevent emergencies during the underground space development, to increase safety and efficiency of mining operations, to ensure the integrity and standard operation of buildings, structures and engineering networks that fall within the zone of their geomechanical influence, as well as environmental protection.

The UIF are defined as the space under the urban areas that provide direct services to the city (for example, sewage disposal, groundwater flow, metro operation, or geothermal energy). The UIF include the rocks and soils formed geologically, as well as man-made structures of different origin and determine the four main resources, namely, space, materials, water and energy. These resources have different degree of recovery, depending on their use and the rate of extraction.

But, as a result of the rapid change in the conditions of economic management, Ukraine has standards and organizational-economic mechanisms for a project and program-oriented and goal-oriented approach to solving the tasks of the industrial and construction state complex development through the construction of new, reconstruction and technical upgrading the existing enterprises and other facilities, which require further improvement.

Analysis of the experience of economically developed world countries in the direction of UIF use, taking into account their legislative base, as well as maintaining the stability of surface soils showed that the need to create a way to the future sustainable use of underground space, given the high density of the surface construction, and the pursuit of economic growth are identified now. As a result, a large-scale study and substantiation of the planning and designing processes for underground infrastructure projects in addition to the underground space in less developed (rural) regions has begun.

An analysis of various statements about stability has shown that planning of infrastructure projects, in addition, the UIF is an important medium for the implementation of both economic growth and social progress. First of all, we define that both economic growth and social progress should not occur at the expense of the environment (e.g., depletion of groundwater level, the quality of rivers, air quality and excessive carbon emissions), and thus it emphasizes the complexity associated with the desire to realize sustainable construction.

It is clear that any project cannot be implemented without appropriate funding. In order to recover the domestic economy as a whole and its main strategic sectors — the fuel and energy complex, the metallurgical industry and agriculture — the significant investments will be required (based on foreign experts' studies results, $ 2.5—3.5 trillion is needed per year) [11]. Therefore, as the experience of highly developed countries shows, for the gradual and effective recovery of the domestic economy, a considerable attention should be paid to a new method of financing the large-scale high-risk investment projects, as well as to project financing.

However, the constant changes in the domestic legislation, financial and political instability in the country are responsible for searching the new directions of the

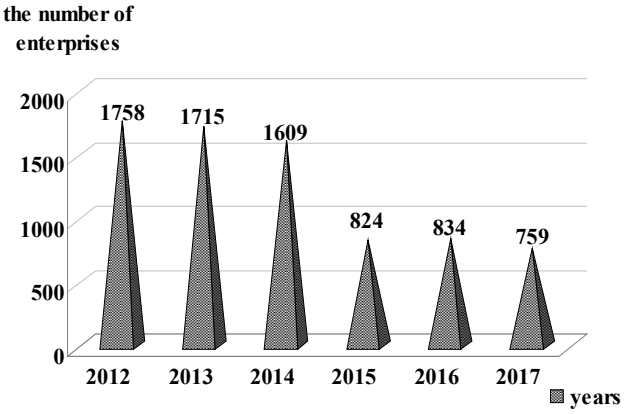

Fig. 1. The number of enterprises engaged in innovation activities

project finance development and the creation of conditions for preferential treatment for both domestic and foreign investors in order to implement sustainable urban designing of UIF with implementation of mixed-use schemes with a high density in Ukraine.

And also use two main approaches of designing: sustainable approach, with the implementation of mixed-use schemes with a high density in Ukraine and comprehensive approach to consideration of the investment project, given its viability, efficiency, availability of adequate resources, the presence of risks, and the like. One of the important factors that, in our opinion, put the brakes on the development of project financing in Ukraine, first of all, are the restrictions of the National Bank on the volumes of investment, the lack of provisions on project financing in the Law on Budget for 2018.

The NBU should establish a system of mandatory reservation for those commercial banks (institutional investors) who actively engaged in investment lending, and check comprehensively the money spent. And, secondly, the stimulation of realisation of sustainable urban designing with the implementation of mixed-use schemes with high-density in Ukraine is constrained by the development of this type of financing under the current unfavourable investment climate.

The general indicators characterizing the innovation activity in Ukraine have a tendency to an increase in the number of innovation enterprises and the volume of expenditures on innovation activity, but, at the same time, there is no real structural change and modernization of the economy (Figs. 1, 2).

Among the reasons for the lack of innovation development is complex business environment in Ukraine. According to the World Bank rating, Ukraine ranks 183th in the world in terms of indicators characterizing the ease of doing business [12]. The most problematic components of this rating are the tax system, the introduction of international trade, the property registration, the setting up and closing of businesses on the territory of Ukraine [13].

The main purpose of the state innovation policy is to create social and economic, organizational and legal conditions for effective reproduction, development and utilization of the scientific and technical potential of Ukraine, ensuring the introduction of modern environmentally friendly, safe, energy- and resource-saving technologies, production and sales of new types of competitive products.

The basic principles of state innovation policy are: orientation on the innovation way of development of the Ukrainian economy; determination of state priorities for innovation development; formation of the legal and regulatory framework in the field of innovation activity; creation of conditions for preservation, development and use of domestic scientific-and-technological, as well as innovation potential; ensuring the interaction between

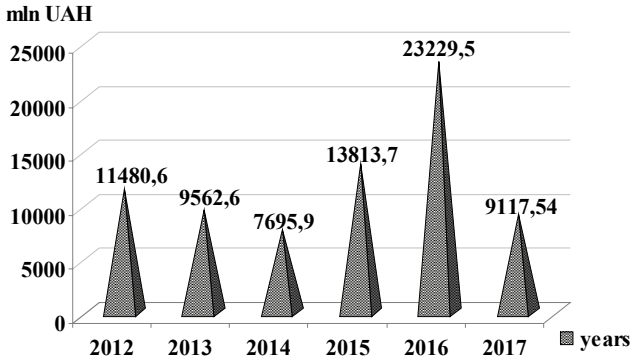

Fig. 2. The volume of industrial enterprises expenditures on innovation, mln. UAH

science, education, manufacturing, financial and credit sphere in the development of innovation activities; effective use of market mechanisms to promote innovation activity, support for entrepreneurship in the research and production sphere; implementation of measures to support of international scientific and technological cooperation, technology transfer, protection of domestic products in the domestic market and its promotion to the external market; financial support, the implementation of favourable credit, tax and customs policy in the field of innovation activity; assistance in development of innovation infrastructure; information assurance of subjects of innovation activity; training of personnel in the field of innovation activity [14].

Based on the above stated purpose of the innovation policy, there is an orientation of innovation policy, which arises depending on the existing conditions and set tasks. Thereof, four directions are distinguished: the innovation policy of 'technological push', the innovation policy of 'market orientation' (based on the fact that the state plays a secondary role in this policy, the main participants are directly business entities that carry out innovation activity on their own initiative); the innovation policy of 'social orientation' aimed at the involvement of the public, as the driving force of innovation development; innovation policy aimed at changing the structure of the economic mechanism.

The combination of these policies with the priority distribution of industries of application is the universal innovation policy. However, in the present conditions of economic reforms, it is necessary to intensify the public activity, to create conditions for the formation of non-governmental organizations and unions, which will have a direct interest in the modernization of the economy and initiate innovation development, and make proposals on changes in the institutional environment of innovation policy. It should be noted that, compared with European ones, Ukrainian innovation networks of business support infrastructure have quite a low level of interaction both within networks and between them. The Ukrainian constituents of infrastructure to support the business and innovation do not unite in the network, since they mostly do not even know about them.

The financing of science based on a residual principle, the lack of incentives for innovation activity and state support of high-tech enterprises, imperfect legislation, total corruption of government officials has led to extremely negative structural changes in the economy, namely, the increase in the share of raw production, low-technology industries and the decline in the share of high-technology industries.

One of the forms of innovations development in the first stages is the creation of Science Parks at universities of the country. Therewith, the Article 65 'On Higher Education' of the Law of Ukraine states that 'the main purpose of scientific, scientific and technical, as well as innovation activity is to obtain new scientific knowledge through research and development and their direction to the creation and implementation of new competitive technologies, types of equipment, materials, etc., in order to provide the innovation development of society, the training of innovation type of specialists'. The Article 66 of the Law of Ukraine defines the conditions for the creation of business incubators, technological Science Parks, etc. [13].

However, the administration of research institutions and universities do not have weighty incentives to intensify their research activity in the framework of the Science Parks and is counting on the old contractual form of work for clients, the number of which decreases with time. An alternative form of contractual form of work performance is the formation of Science Parks at universities, where 'start-ups' were carried out.

It should be noted that the innovation policy management system in Ukraine covers a large number of different ministries, agencies and committees, is uncoordinated, therewith, there is no governing board that as a sole representative could be responsible for innovation policy. The Ministry of Science and Education is responsible for the development and implementation of national policy in the scientific, technological and innovation sphere, as well as the implementation of innovation policy, which is also included into the tasks of the Ministry of Economic Development and Trade.

The National Academy of Sciences, sectoral ministries form their own innovation policy, create tools for implementing the scientific and practical results of their research, have a system of research institutes, sources of funding (their budget), material base and manpower. It is necessary to coordinate the activities of the bodies that implement innovation policy into a single strategy, where each ministry, committees, and institutions are responsible for the stages of economic modernization, the implementation of innovation policy and the consolidation of their functions by legislative regulation. For this purpose, it is advisable to assign the Ministry of Economic Development and Trade as the coordinating authority and consolidate this with the legislative regulation. It is necessary to define as a separate chapter in the Law of Ukraine 'On Innovation Activity' the role and functions of the Ministry for coordinating the activities of government bodies in the implementation of innovation policy.

To form an innovation policy, it is necessary to use a regulatory regime scheme. This scheme is as follows: 'interest — regime — interest' [15] (Fig. 3).

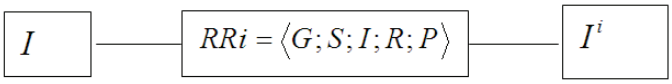

Fig. 3. To form an innovation policy, it is necessary to use a regulatory regime scheme. This scheme is as follows: 'interest — regime — interest'

where: RRi — the regulatory regime for innovation policy as a system;

G — a set of purposes that are planned to achieve with the introduction of this regime;

S — a set of subjects prone to the effect of this regime;

I — a set of rules, regulations, restrictions and conditions (necessary and sufficient) that are required to achieve the purposes declared, since the rules determine the nature of the 'game', establish a means of relationship between the subjects, and introduce restrictions on the use of resources and strategies in the struggle to achieve economic purposes or approval of economic power in the market;

R — a set of resources, which are involved into the implementation process of the innovation regime;

P — a set of policies or strategies aimed at achieving and implementation of objective goals.

Thus, with the help of the regulatory innovation regime, the interest of the innovation development of the country is ensured within the framework of the appropriate established system of incentives and restrictions. A change in each of the components of the

regulatory regime will contribute to the fluctuation of the 'satisfied interest' value.

In Ukraine, there is a problem of a gap between the national innovation programs and regional ones, which is explained by the diversity of innovation potentials of each region and country as a whole. In order to remove these obstacles, it is necessary to define priorities for both national and regional programs. In most EU countries, which began their reforms twenty years ago, it is confirmed that the transition from a regional to a centralized policy of innovation development is a complex process and it is difficult for regions to restructure their innovation policies into the policy of national programs.

After twenty years of reforms, the EU regional programs are behind the national ones; this fact should be taken into account when forming the innovation policy in Ukraine in the process of modernization of the Ukrainian economy. In the EU countries, there are no decisions on the possibility of balancing the interests of regions in a single program, although there are compromise solutions between the relative advantages of multi-regional programs (well-funded, no duplication) and regional programs that are adapted to solving the regional issues of innovation development and consider the specifics of regional development [10]. That is, in the EU a single approach has not been developed to the coordination of regional programs into a single government program.

In Ukraine, the regional innovation policy is dependent and incidental to the state and activities of its industry. During the period of the economy modernization, the state of development of regional innovation policy can be characterized as an initial. It should be noted that the Government of Ukraine has made a lot of efforts to define specific purposes and start certain projects, and the steps have been taken for the development of innovation infrastructure. However, the infrastructure does not meet the requirements of investors, there are no necessary communications, the location of industrial parks is inconvenient for investors (a long distance from the commodity market, transport routes, borders, lack of availability of skilled labour), the lack of information on the availability and state of infrastructure development. The development of regional innovation policy is different in each region; in the western regions and in the centre, more attention is paid to the creation of Science Parks and to their working conditions; in the east — a network of industrial parks was formed, there were attempts to form free economic zones of industrial type. Many regions are experiencing difficulties in attracting investors and the election of the vector of innovation development. This fact should be taken into account when forming the national innovation policy in the context of the economic modernization.

The innovation system of the country can be formed in stages in order to create sustainable urban designing with the implementation of mixed-use schemes with a high density in Ukraine, and their subsequent use and stable functioning. Therefore, at the first stage, it is advisable to build with account of the international experience of the institutional framework, the sustainable urban designing with the implementation of mixed-use schemes with a high density in Ukraine in view of experience and capabilities of the country. At the same time, to make certain changes in the legislative base.

At the second stage, it is advisable to create a plan of priority areas for the realization of sustainable urban designing programs with the implementation of mixed-use schemes with a high density in Ukraine and the provision of tax and customs benefits to investors. Thus, in the Law of Ukraine 'On Innovation Activity', there is also no mechanism for tax benefits to stimulate innovation activity.

CONCLUSIONS

The analysis demonstrates the existence of significant experience in the field of geotechnical substantiation of the possibility to construct underground infrastructure facilities (UIF). The construction technologies and engineering solutions of the underground urban space have already reached a high level. In the near future, a developed urban underground infrastructure will be an essential component of large industrial cities.

The stable UIF development in Ukraine is possible provided the underground facility compatibility with the enclosing rock massif and technological features of construction and operation. The compatibility is based on the development of specific technical and technological safety solutions for the main stages of the technological cycle and at each stage of the 'massif-technology-UIF' system operation. The technical and technological techniques are based on the dynamics of the technical system state during the process of UIF operation.

It is necessary to develop a regulatory framework of the innovation system of the country in order to create stable urban designing with the implementation of mixed-use schemes with a high density in Ukraine, as well as their subsequent introduction and sustainable operation.

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