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CONTACTS

Phone: **+998 50 737 87 88**

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IMPROVING THE EFFICIENCY OF TECHNICAL INFRASTRUCTURE UTILIZATION IN TELECOMMUNICATIONS AND RADIO AND TELEVISION BROADCASTING ENTERPRISES THROUGH DIGITAL TECHNOLOGIES

Ulugbek Nishonovich Khusanov
Associate Professor, Department of Management
Tashkent Institute of Chemical Technology,
Doctor of Economic Sciences
E-mail: xulugbek034@gmail.com
ORCID: 0009-0000-3984-2326

Abstract. The article proposes an integrated index for assessing the efficiency of technical infrastructure utilization, incorporating availability, utilization, and quality. The findings indicate that technical infrastructure in Uzbekistan is expanding faster than the intensity of its utilization, while the primary benefits of digital technologies are achieved through increased infrastructure sharing.

Keywords: technical infrastructure, telecommunications, radio and television broadcasting, utilization efficiency, digital technologies, infrastructure sharing, predictive maintenance, Uzbekistan.

Аннотация. В статье предложен интегральный индекс эффективности использования технической инфраструктуры, учитывающий её доступность, загрузку и качество. Показано, что в Узбекистане инфраструктура развивается быстрее, чем растёт интенсивность её использования, а основной эффект цифровых технологий достигается за счёт расширения совместного использования инфраструктурных объектов.

Ключевые слова: техническая инфраструктура, телекоммуникации, телерадиокоммуникации, эффективность использования, цифровые технологии, совместное использование, предиктивное техническое обслуживание, Узбекистан.

INTRODUCTION

Technical infrastructure—including antenna towers and masts, transmitters, fiber-optic lines, technical buildings, and power supply systems—constitutes the majority of assets held by telecommunications and radio and television broadcasting enterprises. Its development requires substantial capital investment, while its profitability depends not on the number of facilities constructed but on how fully and reliably they are utilized. Therefore, amid rapid network expansion, improving the efficiency of existing infrastructure utilization has become a key priority.

In Uzbekistan, communications infrastructure has expanded significantly over the past five years. Between 2020 and 2025, the number of mobile communication base stations increased from 31,700 to 98,700, the length of fiber-optic lines grew approximately fivefold to 346,600 km, and international internet bandwidth increased from 1,200 to 4,400 Gbit/s [8]. Digital television, supported by 494 DVB-T2 transmitters, provides coverage to the entire population [6]. The volume of telecommunications services reached UZS 7.7 trillion in January–April 2025, representing an increase of 14.4% [1], while investment in the sector reached UZS 3.1 trillion in the first quarter of 2026 [12]. However, infrastructure expansion and utilization are progressing at substantially different rates, highlighting opportunities to improve the systematic measurement of infrastructure utilization at the enterprise level. This constitutes the central research problem.

The objective of this study is to substantiate approaches to improving the efficiency of technical infrastructure utilization in telecommunications and radio and television broadcasting enterprises through digital technologies. The scientific novelty of the study lies in three contributions: the development of an integrated infrastructure

utilization efficiency index combining availability, utilization, and quality; the identification, based on data for 2020–2025, of infrastructure expansion outpacing its utilization; and the demonstration, through a digitalization program model, that the principal economic benefits arise from increased infrastructure sharing rather than reductions in operating costs.

LITERATURE REVIEW

The methodological foundation for assessing equipment utilization efficiency is the Overall Equipment Effectiveness (OEE) indicator introduced by S. Nakajima [9] within the Total Productive Maintenance framework. OEE is calculated as the product of availability, performance, and quality, enabling the identification of hidden capacity losses. ISO 55000 [7] defines asset management as an activity aimed at realizing value from assets throughout their life cycle and emphasizes the need to align decisions concerning costs, risks, and service levels.

For telecommunications infrastructure, infrastructure sharing represents a major opportunity to increase utilization. T. Frisanco et al. [4] demonstrated that sharing passive infrastructure—including towers, buildings, and power supply systems—significantly reduces operators' capital and operating expenditures. The GSMA report [5] identifies infrastructure sharing as a key instrument for reducing costs and expanding network coverage. In Uzbekistan, this approach is at an emerging stage: Beeline has transferred approximately 4,000 towers to a separate company, while tower companies own only 1.3% of the 33,350 towers in Central Asia [2].

Digital technologies provide tools for improving all components of infrastructure efficiency. F. Tao et al. [11] demonstrated that digital twins enable real-time modeling of asset conditions and utilization, thereby optimizing infrastructure development decisions. T. Carvalho et al. [3] reviewed the application of machine learning to predictive maintenance and highlighted its effectiveness in reducing unplanned equipment failures. Among domestic studies, U. N. Khusanov [13] identified the principal directions of telecommunications network development, including digitalization, fiber-optic network expansion, and computerization, while A. B. Suyunov [10] examined the regulatory and legal foundations of sectoral development. However, these studies did not provide an integrated assessment of infrastructure utilization efficiency or quantify the contribution of digital technologies to its improvement.

RESEARCH METHODOLOGY

By analogy with the OEE indicator [9], an integrated infrastructure utilization efficiency index is proposed:

$$IEI = A \cdot U \cdot Q \cdot 100, \quad U = n / n_{max} \qquad (1)$$

where A is the availability coefficient (the proportion of time during which the infrastructure facility is operational), U is the utilization coefficient, n is the average number of tenants (operators and broadcasters) per facility, n_{max} is the technically permissible maximum number of tenants (assumed to be 3), and Q is the proportion of time during which service quality meets regulatory standards. The economic efficiency of infrastructure utilization is measured by the cost per tenant placement:

$$c = (M + E + O_d) / (N \cdot n) \qquad (2)$$

where M and E represent maintenance and electricity costs, respectively, O_d represents the operating costs of digital systems, and N is the number of infrastructure facilities. The economic impact of the digitalization program is evaluated using net present value (NPV):

$$NPV = \Sigma_{t=0\ldots T} (\Delta R_t + \Delta S_t - I_t - O_{d,t}) / (1 + r)^t \qquad (3)$$

where ΔR_t represents additional revenue from tenant placements, ΔS_t represents savings on maintenance and electricity costs, and I_t represents investment expenditures. The calculation was performed for a hypothetical network of 1,000 infrastructure facilities over a seven-year period, using a discount rate of 16%. The model parameters are hypothetical and are intended to demonstrate the methodology; the robustness of the findings was assessed through sensitivity analysis.

Artificial intelligence (AI) tools were used to a limited extent, accounting for approximately 10% of the overall research preparation process. Their use was primarily confined to language refinement, technical editing, and structural support. The selection of research methods, analysis and interpretation of findings, formulation of scientific conclusions, and overall responsibility for the research content remained entirely with the author.

ANALYSIS AND RESULTS

Relationship Between Infrastructure Growth and Utilization. A comparison of indicators for 2020 and 2025

reveals that infrastructure expansion outpaced its utilization (Table 1).

Table 1
Indicators of Telecommunications Infrastructure Development in Uzbekistan

Indicator	2020	2025	Growth factor
Mobile communication base stations, thousand	31.7	98.7	3.1
Length of fiber-optic communication lines, thousand km	≈ 69	346.6	≈ 5.0
Broadband access ports, million	2.9	6.3	2.2
International internet bandwidth, Gbit/s	1,200	4,400	3.7
Broadband access ports per 1 km of fiber-optic lines	≈ 42	18.2	≈ 0.43

Source: [8]; the length of fiber-optic lines in 2020 and the indicators in the final row were calculated by the author.

The length of fiber-optic lines increased approximately fivefold, while the number of broadband access ports grew by only 2.2 times, resulting in a 2.3-fold decrease in the number of ports per kilometer of fiber-optic lines. This trend is typical of the active network construction phase and indicates substantial potential for further utilization and revenue generation from the newly established capacity. A similar situation is observed in antenna towers and masts: given the limited share of tower companies [9], most facilities serve a single operator.

Impact of the Digitalization Program. For a hypothetical network, performance indicators were calculated before and after implementing a comprehensive set of digital technologies, including remote monitoring and predictive maintenance, intelligent energy management, a digital infrastructure asset register, and a tenant placement platform (Table 2).

Table 2
Infrastructure Utilization Efficiency Indicators for a Hypothetical Network

Indicator	Before digitalization	After digitalization (Year 7)
Availability coefficient, *A*, %	99.50	99.90
Downtime per facility, hours/year	43.8	8.8
Average number of tenants per facility, *n*	1.3	1.8
Quality coefficient, *Q*, %	97.0	99.0
Infrastructure Efficiency Index (IEI), %	41.8	59.3
Unit cost per tenant placement, *c*, million UZS/year	36.9	25.5

Source: Author's calculations based on Equations (1)–(2); annual costs per facility: maintenance — UZS 18 million and electricity — UZS 30 million.

The Infrastructure Efficiency Index increases from 41.8% to 59.3%, the unit cost per tenant placement decreases from UZS 36.9 million to UZS 25.5 million annually, and facility downtime is reduced fivefold. The digitalization program, requiring an investment of UZS 60.0 billion, demonstrates economic viability, with a net present value (NPV) of UZS 35.0 billion and an internal rate of return (IRR) of 32.2%.

The composition of the economic benefits indicates that the largest contribution comes from increased infrastructure sharing. Once the program reaches its target operating level, additional annual revenue from tenants amounts to UZS 30.0 billion, while savings on maintenance and electricity total only UZS 8.1 billion. If the number of tenants remains unchanged, the program's NPV becomes negative (UZS −56.3 billion). Sensitivity analysis confirms this finding: a 20% change in either the increase in the number of tenants or the tenant placement fee changes NPV by ±UZS 18.3 billion, whereas an equivalent change in electricity cost savings affects NPV by only ±UZS 2.7 billion (Figure 1).

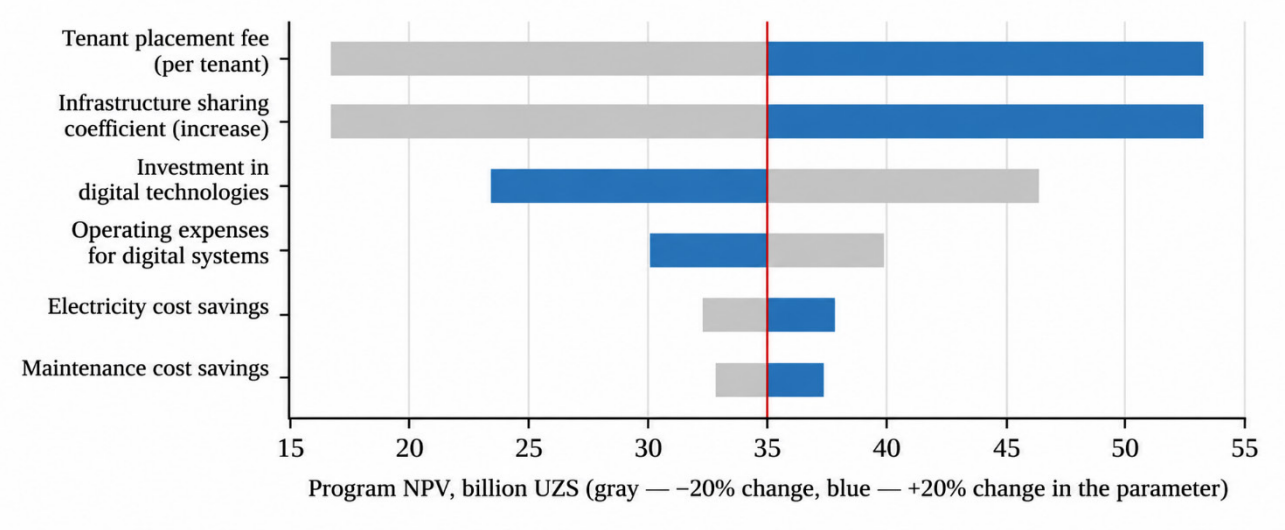


Figure 1. Sensitivity of the Digitalization Program's NPV to ±20% Changes in Parameters[1]

The findings provide further insight into the role of digital technologies in infrastructure management. A common approach considers these technologies primarily as a means of reducing costs through predictive maintenance [3] and electricity savings. However, the model demonstrates that cost reduction alone is insufficient for infrastructure enterprises: given the high proportion of fixed costs, facility utilization is of decisive importance. Digital technologies increase utilization indirectly by creating favorable conditions for infrastructure sharing. A digital asset register containing information on available tower space, load capacity, and power supply; a digital twin of the network [11] for assessing the feasibility of equipment placement; and an electronic platform for submitting and approving tenant applications reduce the time and costs associated with connecting a new operator. This is consistent with findings identifying infrastructure sharing as a major opportunity for cost reduction [4-5].

The proposed Infrastructure Efficiency Index (IEI) enables a transition from asset accounting to the management of infrastructure utilization in accordance with the principles of ISO 55000 [7]. The digital tools and the performance indicators they influence are summarized in Table 3.

Table 3
Digital Technologies for Improving Infrastructure Utilization Efficiency

Technology	IEI Component	Key Performance Indicator
Remote monitoring and predictive maintenance	A — Availability	Facility downtime; failure resolution time
Digital asset register and network digital twin	U — Utilization	Available capacity; number of tenants
Electronic tenant placement platform	U — Utilization	Tenant connection time
Intelligent energy management	c — Costs	Energy consumption per facility
Service quality analytics	Q — Quality	Proportion of time during which service quality meets regulatory standards

Source: Developed by the author.

CONCLUSION AND RECOMMENDATIONS

The study demonstrated that between 2020 and 2025, Uzbekistan's telecommunications infrastructure expanded faster than its utilization, with the number of broadband access ports per kilometer of fiber-optic lines decreasing by a factor of 2.3. This trend reflects the rapid development of communications networks and indicates considerable potential for improving the utilization of existing infrastructure capacity. The proposed integrated Infrastructure Efficiency Index (IEI), incorporating availability, utilization, and quality, provides a comprehensive approach to assessing infrastructure performance and identifying opportunities for more

1 Source: Author's calculations.

efficient asset management.

The modeling results demonstrated that implementing a digitalization program increases the IEI from 41.8% to 59.3%, reduces operating costs per tenant placement, and improves infrastructure reliability. The program also demonstrates economic viability, with the principal benefits arising from increased infrastructure sharing rather than operational cost savings alone. These findings emphasize that digital transformation should focus not only on improving technical performance but also on creating conditions for more intensive and economically productive infrastructure utilization. Based on the research findings, three measures are proposed.

1. Integrate the IEI into the asset management system. Telecommunications and radio and television broadcasting enterprises should systematically calculate the Infrastructure Efficiency Index for each facility and incorporate it into the key performance indicators of management. Regular monitoring of availability, utilization, and service quality would enable enterprises to identify underutilized infrastructure, assess operational performance, and make more informed decisions regarding maintenance, modernization, and capacity allocation. The application of a unified performance indicator would also facilitate comparisons between infrastructure facilities and support the development of more transparent and results-oriented asset management practices.

2. Establish a digital asset register and an open tenant placement platform. Develop a unified digital register of antenna towers and masts, technical buildings, and fiber-optic lines, including information on available capacity, technical characteristics, and infrastructure utilization. The register should be integrated with an electronic platform enabling telecommunications operators and broadcasters to submit, review, and obtain approval for tenant placement applications. Such an approach would simplify access to information about available infrastructure, reduce the time required to coordinate equipment placement, and create favorable conditions for expanding infrastructure sharing. Consequently, existing facilities could accommodate additional operators without requiring proportional increases in capital investment.

3. Prioritize digital projects according to their impact on infrastructure utilization. When selecting and financing digital transformation projects, enterprises should evaluate their expected contribution to all components of the IEI, particularly infrastructure availability, utilization, and service quality. Priority should be given to projects that facilitate infrastructure sharing, increase the number of tenants per facility, and improve the economic returns generated by existing assets. At the same time, investments in remote monitoring, predictive maintenance, intelligent energy management, and digital infrastructure management systems should be assessed in terms of their combined operational and financial benefits. This approach would help enterprises allocate investment resources more effectively and strengthen the long-term economic sustainability of their infrastructure.

Overall, the proposed measures provide a basis for improving the efficiency of technical infrastructure utilization through the systematic application of digital technologies. Their implementation would support more effective use of existing assets, encourage infrastructure sharing, improve service reliability, and enhance the financial performance of telecommunications and radio and television broadcasting enterprises in Uzbekistan.

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