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REVIEW ARTICLE

DIGITAL BUILDING PASSPORT IN AZERBAIJAN: A SYSTEMATIC LITERATURE REVIEW

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Abstract. *Azerbaijan's housing stock is largely composed of Soviet-era prefabricated panel buildings (1950s–1990s), characterized by poor thermal performance and the absence of digital documentation. Although a national building energy certification system was introduced in 2022, a comprehensive Digital Building Passport (DBP) framework adapted to post-Soviet conditions has not yet been developed. This study presents a systematic literature review aimed at identifying advanced European DBP and Building Renovation Passport (BRP) models, analyzing their data structures and implementation barriers, and developing a context-adapted DBP model for Azerbaijan. The review follows the PRISMA 2020 guidelines and is based on a Scopus search, resulting in a final sample of 40 peer-reviewed studies published between 2018 and 2026. The results reveal a rapid increase in research activity, with 44% of publications appearing in 2025, reflecting the impact of recent European policy developments. Thematic analysis shows that 59% of studies focus on digital building logbook data structures, while 30% address building renovation passports. Across the reviewed literature, four key implementation barriers are consistently identified: data interoperability, data quality limitations, administrative fragmentation, and low stakeholder engagement. The main scientific contribution of this study is the development of a three-level conceptual DBP model tailored to the Azerbaijani context, integrating static building data, renovation history based on standardized typologies, and long-term renovation planning. From a practical perspective, the proposed model provides a scalable and modular solution suitable for data-constrained environments, supporting a phased transition from static certification systems to dynamic, lifecycle-oriented digital building management.*

Keywords: *digital passport, renovation passport, Azerbaijan, systematic review, PRISMA, energy renovation.*

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ӘЗІРБАЙЖАНДАҒЫ ЦИФРЛЫҚ ҒИМАРАТ ПАСПОРТЫ: ӘДЕБИЕТТЕРГЕ ЖҮЙЕЛІК ШОЛУ

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Аңдатпа. *Әзірбайжанның тұрғын үй қоры негізінен кеңес дәуіріндегі алдын ала құрастырылған панельді ғимараттардан (1950-1990 жылдар) тұрады, олар жылу өткізгіштіктің нашарлығымен және сандық құжаттаманың болмауымен сипатталады. 2022 жылы ұлттық ғимараттардың энергетикалық сертификаттау жүйесі енгізілгенімен, посткеңестік жағдайларға бейімделген кешенді сандық ғимарат паспортының (DBP) құрылымы әлі әзірленбеген. Бұл зерттеуде еуропалық DBP және ғимараттарды жөндеу паспортының (BRP) озық үлгілерін анықтауға, олардың деректер құрылымдары мен енгізу кедергілерін талдауға және Әзірбайжан үшін контекстке бейімделген DBP моделін әзірлеуге бағытталған жүйелі әдебиеттерге шолу ұсынылған. Шолу PRISMA 2020 нұсқауларына сәйкес келеді және Scopus іздеуіне негізделген, нәтижесінде 2018 және 2026 жылдар аралығында жарияланған 40 сараптамалық зерттеудің соңғы үлгісі пайда болды. Нәтижелер зерттеу қызметінің тез өскенін көрсетеді, жарияланымдардың 44%-ы 2025 жылы пайда болды, бұл соңғы еуропалық саясаттағы өзгерістердің әсерін көрсетеді. Тақырыптық талдау зерттеулердің 59%-ы сандық ғимарат журналының деректер құрылымдарына бағытталғанын, ал 30%-ы ғимараттарды жөндеу паспорттарын қарастыратынын көрсетеді. Қарастырылған әдебиеттерде төрт негізгі іске асыру кедергісі үнемі анықталған: деректердің өзара әрекеттесуі, деректер сапасының шектеулері, әкімшілік фрагментация және мүдделі тараптардың төмен қатысуы. Бұл зерттеудің негізгі ғылыми үлесі - статикалық ғимарат деректерін, стандартталған типологияларға негізделген жөндеу тарихын және ұзақ мерзімді жөндеуді жоспарлауды біріктіретін Әзірбайжан контекстіне бейімделген үш деңгейлі тұжырымдамалық ДБП моделін әзірлеу. Практикалық тұрғыдан алғанда, ұсынылған модель деректермен шектелген орталарға қолайлы масштабталатын және модульдік шешімді ұсынады, статикалық сертификаттау жүйелерінен динамикалық, өмірлік циклге бағытталған сандық ғимараттарды басқаруға кезең-кезеңмен көшуді қолдайды.*

Түйін сөздер: *цифрлық паспорт, жөндеу паспорты, Әзірбайжан, жүйелі шолу, PRISMA, энергетикалық жаңарту.*

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ОБЗОРНАЯ СТАТЬЯ

ЦИФРОВОЙ ПАСПОРТ ЗДАНИЯ В АЗЕРБАЙДЖАНЕ: СИСТЕМАТИЧЕСКИЙ ЛИТЕРАТУРНЫЙ ОБЗОР

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Аннотация. *Жилищный фонд Азербайджана в значительной степени состоит из сборных панельных зданий советской эпохи (1950-е–1990-е годы), характеризующихся низкими теплоизоляционными характеристиками и отсутствием цифровой документации. Хотя в 2022 году была введена национальная система энергетической сертификации зданий, комплексная система цифровых паспортов зданий (ЦПЗ), адаптированная к постсоветским условиям, до сих пор не разработана. В данном исследовании представлен систематический обзор литературы, направленный на выявление передовых европейских моделей ЦПЗ и паспортов реконструкции зданий (ППЗ), анализ их структуры данных и барьеров внедрения, а также разработку адаптированной к контексту модели ЦПЗ для Азербайджана. Обзор проводится в соответствии с рекомендациями PRISMA 2020 и основан на поиске в базе данных Scopus, в результате чего в окончательную выборку вошли 40 рецензируемых исследований, опубликованных в период с 2018 по 2026 год. Результаты показывают быстрый рост исследовательской активности: 44% публикаций появились в 2025 году, что отражает влияние последних изменений в европейской политике. Тематический анализ показывает, что 59% исследований посвящены структурам данных цифровых журналов учета зданий, а 30% – паспортам реконструкции зданий. В рассмотренной литературе последовательно выделяются четыре ключевых барьера внедрения: совместимость данных, ограничения качества данных, административная фрагментация и низкий уровень вовлеченности заинтересованных сторон. Основной научный вклад данного исследования заключается в разработке трехуровневой концептуальной модели цифрового управления зданиями (DBP), адаптированной к азербайджанскому контексту, интегрирующей статические данные о зданиях, историю реконструкции на основе стандартизированных типологий и долгосрочное планирование реконструкции. С практической точки зрения, предложенная модель представляет собой масштабируемое и модульное решение, подходящее для условий с ограниченными данными, поддерживающее поэтапный переход от статических систем сертификации к динамичному, ориентированному на жизненный цикл цифровому управлению зданиями.*

Ключевые слова:. *цифровой паспорт, паспорт реновации, Азербайджан, систематический обзор, PRISMA, энергетическая реновация.*

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1 INTRODUCTION

Buildings account for approximately 40% of energy consumption and 36% of CO_2 emissions in the European Union, making the construction sector a central component of decarbonization strategies [1]. In this context, improving the energy performance of existing buildings has become a key priority, particularly through the development of digital tools supporting lifecycle-based decision-making.

Recent studies emphasize the growing role of digital building passports (DBPs) and digital building logbooks as integrated information systems that consolidate technical, environmental, and operational data across the building lifecycle [9; 10]. These tools are increasingly viewed as essential instruments for enabling deep renovation strategies, supporting policy implementation, and facilitating data-driven decision-making in the building sector [22].

Within the European context, the concept of DBP has evolved significantly in recent years, particularly under the influence of the "Renovation Wave" initiative and the revised Energy Performance of Buildings Directive [11], which formalizes the role of building renovation passports as a key policy instrument. Contemporary research focuses on the development of data architectures, interoperability frameworks, and integration with emerging technologies such as Building Information Modeling (BIM) and digital twins [17]. At the same time, several studies highlight persistent challenges related to data quality, information system fragmentation, and user engagement [4; 6].

Despite these advances, the majority of existing research is concentrated on Western European countries with relatively mature digital ecosystems and well-developed regulatory frameworks [5; 18]. Consequently, the applicability of DBP models to other contexts–particularly post-Soviet countries–remains insufficiently explored. This represents a critical limitation, as these regions are characterized by distinct structural conditions, including outdated building stock, limited digital documentation, and fragmented ownership structures [15; 21].

Azerbaijan exemplifies this gap. A significant share of its housing stock consists of Soviet-era panel buildings constructed between the 1950s and 1990s, which are characterized by low thermal performance and a lack of reliable technical documentation [16]. In response to the need to improve energy efficiency, a national building passport system was introduced in 2022, aiming to reduce energy consumption by up to 30% by 2030 [14]. However, this system currently operates primarily as a static certification tool, similar to the European Energy Performance Certificate (EPC), and lacks the dynamic and integrative capabilities associated with DBPs [12; 13].

At the same time, the Azerbaijani context presents both challenges and opportunities for DBP implementation. On the one hand, the absence of digital building records requires significant efforts for data collection and system development. On the other hand, the prevalence of standardised Soviet-era building typologies creates favourable conditions for developing template-based, scalable data models.

Therefore, the key research gap lies in the lack of context-adapted DBP frameworks that account for the specific characteristics of post-Soviet housing stock and data-constrained environments. Existing European models cannot be directly transferred without significant modification, highlighting the need for tailored approaches that integrate international best practices with local conditions.

In this context, this study aims to identify the most developed European DBP models and their data structures, analyze key implementation barriers reported in the literature, and assess their applicability to the Azerbaijani context, leading to the development of a context-adapted conceptual DBP model for the national housing stock.

Unlike existing reviews, this study synthesizes the fragmented data on Digital Building Logbooks (DBL) specifically for regions with transitioning energy economies. The scientific contribution lies in the development of a conceptual framework that integrates energy performance certificates (EPC) with decarbonization pathways.

2 MATERIALS AND METHODS

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This study was conducted as a systematic literature review in accordance with the PRISMA 2020 (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines [11,20]. The review protocol was registered on the Open Science Framework (OSF) to ensure transparency and reproducibility.

The literature search was performed in the Scopus database on February 11, 2026. The search strategy was developed using a structured Boolean query applied to titles, abstracts, and keywords (TITLE-ABS-KEY), as follows: ("digital building logbook" OR "building logbook" OR "digital building passport" OR "building passport" OR "renovation passport") AND ("energy efficiency" OR "building renovation" OR "decarbonization" OR "Azerbaijan"). The inclusion and exclusion criteria were defined prior to the screening process (Table 1).

Table 1 - Inclusion and exclusion criteria

Inclusion criteria	Exception criteria
Publications published between 2015 and 2026	Publications published before 2015
Journal articles, review articles, and book chapters	Conference papers and conference reviews
Publications in English or Russian	Publications in other languages
Studies related to digital building logbooks, building passports, EPC, and renovation strategies	Studies unrelated to the topic (e.g., transport, manufacturing)
Residential or mixed-use buildings	Exclusively industrial buildings
Full-text availability	Abstract only

The following inclusion criteria were applied: 1- publications published between 2015 and 2026; 2- journal articles, review papers, and book chapters; 3- studies written in English or Russian; 4- studies addressing digital building logbooks, building passports, energy performance certification, or renovation strategies; and 5- studies focused on residential or mixed-use buildings.

Selection Process and Data Synthesis. The screening process was managed using the Rayyan platform for independent and blinded review [19]. The selection evolved through four stages:

1. Identification: A total of 116 records were initially identified. After the automatic and manual removal of 30 duplicates, 86 unique records remained.
2. Screening: The titles and abstracts of the 86 records were screened against the inclusion criteria. At this stage, 21 records were excluded as they were outside the geographical or thematic scope (e.g., focusing on industrial manufacturing).
3. Eligibility: The remaining 65 full-text articles were assessed for eligibility. During this phase, 25 records were excluded: 20 were identified as conference papers (not meeting the document type criterion) and 5 lacked full-text availability.
4. Included: A final set of 40 peer-reviewed sources was included in the systematic review.

The complete selection process is visualized in the PRISMA flow diagram (Figure 1).

3 RESULTS AND DISCUSSION

The 86 records identified cover the period 2018–2026, with a pronounced concentration in 2025 (n = 38; 44%). This sharp increase in publication activity indicates a transition of the DBP concept from a theoretical framework to an actively developing research field, largely driven by regulatory changes, particularly the adoption of the revised Energy Performance of Buildings Directive. The distribution of document types (Table 2) reveals a high proportion of conference publications (54% combined), which suggests that the field is still in a formative stage. Such a structure of scientific output typically reflects an emerging research domain, where concepts and methodologies are actively being tested but have not yet reached full consolidation in high-impact journal publications.

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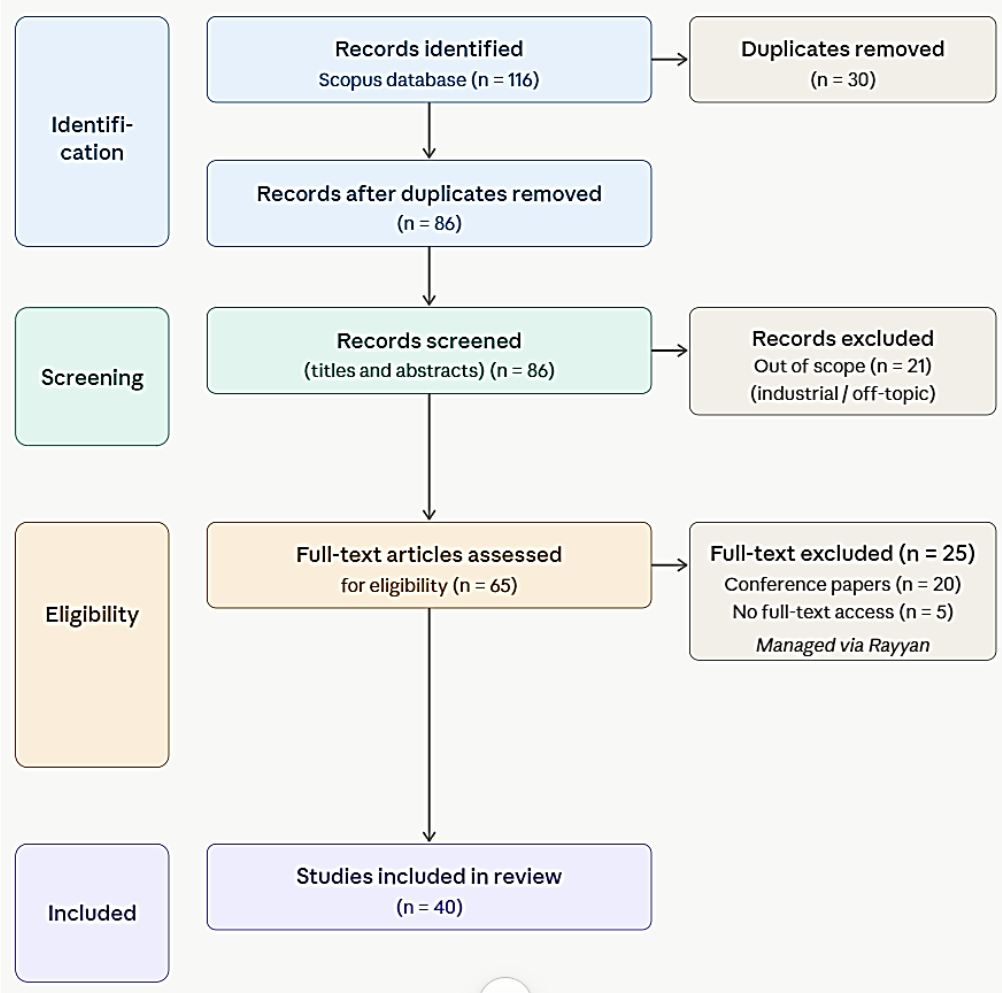


Figure 1 - PRISMA flow diagram of the systematic literature review process [Authors' material]
Note: DBP – Digital Building Passport; BRP – Building Renovation Passport;
EPC – Energy Performance Certificate

Table 2 - Distribution of publications by document type, n = 86 [Authors' material].

№	Document type	Number of publications	Share, %
1	Journal articles	31	36%
2	Conference papers	28	33%
3	Conference reviews	18	21%
4	Review articles	8	9%
5	Book chapters	1	1%
6	Total	86	100%

Thematic classification further supports this observation. The predominance of studies related to building documentation and data structures (59%) indicates that the current research focus is primarily on the development of data frameworks, rather than on large-scale implementation or performance evaluation. In contrast, studies addressing renovation passports (30%) remain less represented, suggesting that applied research on implementation strategies is still evolving.

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An analysis of leading journals shows that the topic is concentrated within a relatively narrow group of specialized outlets (e.g., *Buildings*, *Energy and Buildings*, *Sustainability*), indicating limited diffusion into broader interdisciplinary or policy-oriented journals. This may reflect the technical nature of the field, as well as its current positioning at the intersection of engineering and digitalization. The citation analysis highlights a clear intellectual structure of the field. Foundational works [21] focus on conceptualizing renovation passports and identifying barriers, while more recent studies [17; 7] shift toward digital integration, including BIM, digital twins, and lifecycle data management. This evolution suggests a gradual transition from conceptual exploration to technological operationalization of DBP systems.

An analysis of the reviewed literature allows us to identify a number of established European implementations of the DBP. [8] conducted a comparative analysis of models developed within the framework of the European Commission initiatives (iBRoad, ALDREN, X - tendo), revealing significant heterogeneity in data structures and management models.

[7] proposed a comprehensive digital building renovation passport (DBRP) structure comprising eight main data categories, including a material passport component, implemented using a hybrid storage architecture. A further development of this approach is presented in the work of [6], who proposed an extended model of a digital building renovation passport (DBP), including 34 categories and 163 attributes, aimed at supporting renovation roadmaps and monitoring the quality of the indoor environment after interventions.

Along with the development of data structures, the literature consistently identifies key requirements for digital knowledge bases. For example, [4; 2] identify interoperability, data quality, and information management as the most persistent barriers to the widespread adoption of digital knowledge bases. These findings are consistent with the results of a pan-European survey which considers interoperability, data reliability, and alignment with EU digital strategies as fundamental conditions for the development of standardized digital knowledge bases. To identify the qualitative differences between the DBP and traditional assessment tools, Table 3 presents a comparison of the building energy certificate and the digital building passport.

Table 3 - Key differences between EPC and DBP (compiled by the authors based on [18; 7; 22])

Criterion comparisons	Energy certificate of buildings	Digital building passport
Type data	Static - a snapshot at the time of inspection	Dynamic - updated magazine events
Lifecycle coverage	Limited - Current Class energy efficiency	Complete - from design to disposal
Target use	Correspondence standards and reporting	Justification for deep renovation and long-term planning

Despite the significant potential of the DBP (Table 3), literature analysis allows us to identify four consistently reproducible categories of implementation barriers:

– *Firstly*, problems of data interoperability caused by the fragmentation of national databases, the lack of standardized information exchange formats and the incompatibility of outdated administrative systems with modern digital solutions [3; 7];

– *Secondly*, limitations in data quality, including incomplete historical information and discrepancies between certified and actual energy performance of buildings;

– *Thirdly*, administrative and managerial barriers, expressed in the uncertainty of regulatory requirements, the complexity of the ownership structure and the shortage of qualified personnel;

– *Fourthly*, low involvement of owners, due to the fact that existing versions of the DBP are focused mainly on technological aspects and do not sufficiently take into account behavioral factors when making decisions on renovation.

The literature reviewed allows us to formulate a number of conclusions applicable to the Azerbaijani context. The energy certification system introduced in 2022 creates an institutional foundation

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for further digitalization. The homogeneity of Soviet-era building typologies facilitates the development of standardized data templates, while international experience can be used as benchmarks for implementation.

In particular, the German iSFP model appears to be most applicable in the short term, while the Belgian Woningpas system can be considered a long-term benchmark. However, studies of the thermal performance of buildings in Baku and experience with energy audits of university campuses indicate the need to adapt the parameters of the central heating system to local climatic and operational conditions [20].

Taken together, the reviewed models demonstrate a clear trend toward increasing complexity and data granularity. While early approaches focused on basic data aggregation, more recent models incorporate multi-layered data architectures and lifecycle integration. However, this increasing complexity also introduces significant challenges related to data interoperability and usability. Thus, a key trade-off emerges between model comprehensiveness and practical applicability, which remains insufficiently resolved in the current literature [21].

Based on a systematic analysis of European DBP models, as well as the data structures and functional requirements identified in the literature, a three-level conceptual model of the Digital Building Passport (DBP) for the housing stock of Azerbaijan is proposed [22; 23].

The choice of a three-level structure is grounded in the consistent representation of DBP systems in the reviewed studies, which typically encompass three key dimensions: (i) basic building characteristics, (ii) the dynamics of building transformation, and (iii) long-term renovation planning.

The first level – the *Building Data Category* – includes static characteristics such as year of construction, structural system, total area, and number of apartments, as well as data from the national building certification system introduced in Azerbaijan in 2022.

The second level – the *Renovation History Category* – captures records of interventions, maintenance activities, and material specifications, structured according to standardized Soviet-era building typologies.

The third level – the *Renovation Planning Category* – incorporates prospective renovation roadmaps aligned with national energy efficiency targets for 2030, reflecting the transition toward long-term decarbonization strategies (Figure 2).

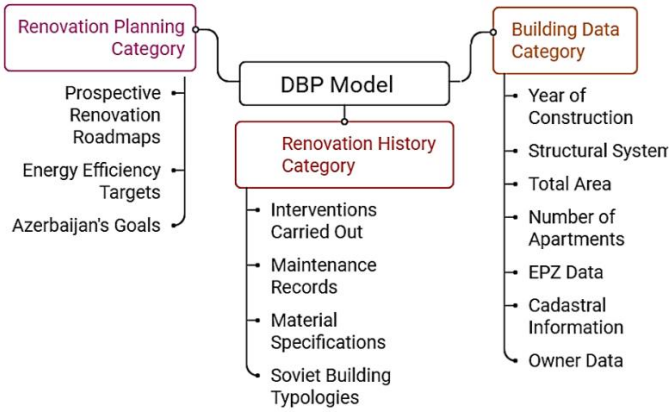


Figure 2 - Conceptual model of the Digital Building Passport (DBP) for the housing stock of Azerbaijan [Authors' materia]

The proposed framework is consistent with existing European approaches that emphasize lifecycle data integration and multi-layered data structures. However, in contrast to highly detailed and data-intensive models, which may include over 160 attributes, the present model adopts a more hierarchical and modular structure, prioritizing scalability and practical implementation. This distinction is critical, as previous studies demonstrate that excessive data complexity may limit real-world applicability due to constraints in data availability and user.

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A key finding of this study is that the implementation of DBP systems is shaped by systemic contradictions that emerge at the intersection of technological potential and contextual limitations. These contradictions, identified both in European studies and in the Azerbaijani context, are primarily related to data interoperability, data quality, institutional readiness, and user engagement.

In Azerbaijan, these challenges are further intensified by the limited availability of digital building records and the fragmentation of existing information systems, which aligns with previously identified barriers in DBP implementation. At the same time, the dominance of standardized Soviet-era building typologies creates a distinct structural condition that differs significantly from Western European contexts, where building stock is typically more heterogeneous [7].

This structural specificity creates favorable conditions for the development of template-based DBP models, representing a key contribution of this study. Unlike existing European approaches, which primarily focus on flexible but complex data architectures, the proposed model leverages typological uniformity to support standardization and scalability.

At the same time, the findings confirm a fundamental tension between standardization and adaptability, widely discussed in the literature [18; 23]. While standardized data structures are essential for large-scale implementation, effective renovation planning requires adaptation to local climatic and operational conditions. This is particularly relevant for Azerbaijan, where climatic diversity necessitates differentiated renovation strategies despite structural similarities in the housing stock [1; 24]. These contradictions are systematized in Table 4.

Table 4 - Contradictions in the adaptation of DBP for Azerbaijan [Authors' material]

Implementation potential, Favorable factors	Barriers and limitations, Technological risks
Homogeneity of typologies: Soviet series allow the use of standardized data templates.	The paradox of standardization: the buildings are structurally similar, but Azerbaijan's climatic diversity (from semi-deserts to highlands) requires climate-adapted renovation modules.
Institutional framework: the current passport system has been in effect since 2022.	Data quality: significant discrepancies between archival documents and the actual state of objects.
Technological potential: readiness for the implementation of BIM and digital twins.	Human factor: low owner involvement and a shortage of qualified personnel for digital audit.

Another important dimension concerns the balance between technological complexity and user accessibility. Although advanced solutions such as BIM and digital twins offer significant potential for DBP development [17; 10; 25], their implementation in the Azerbaijani context is constrained by limited institutional capacity and low stakeholder engagement. This highlights the importance of phased implementation strategies, starting with simplified and user-oriented solutions, followed by gradual integration of more advanced digital technologies.

Overall, the findings demonstrate that the direct transfer of European DBP models to the Azerbaijani context is not feasible without substantial adaptation. Structural differences in data availability, institutional maturity, and building stock composition require the development of context-sensitive implementation pathways rather than the replication of existing frameworks.

From a practical perspective, the proposed three-level model provides a scalable and adaptable solution for the gradual digitalization of the building sector in Azerbaijan. Its hierarchical structure enables the integration of incomplete and heterogeneous data, which is a critical requirement in data-constrained environments.

In this regard, hybrid approaches that combine standardized data templates with adaptive decision-support mechanisms represent the most promising direction for future DBP development, both in Azerbaijan and in other countries with similar post-Soviet building stock characteristics (Table 5).

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Table 5 - Comparison of the proposed DBP model for Azerbaijan with existing European frameworks [Author's material]

Feature	Standard European DBP (iBRoad, ALDREN)	Proposed context-adapted DBP, Azerbaijan	Scientific value of the proposal
Data Architecture	Highly fragmented, focus on heterogeneous historical buildings.	Template-based, leveraging standardized Soviet-era building series (e.g., 1-464, 1-467).	High scalability: allows for rapid digitalization of 60-70% of the housing stock using master-templates.
Granularity	Extreme detail (up to 160+ attributes), high data demand.	Hierarchical 3-level structure (Basic, History, Planning) with priority attributes.	Practicality: functions effectively even in "data-constrained" environments with limited archival records.
Climate Adaptation	Generally uniform within EU zones.	Differentiated modules for Azerbaijan's 9 climate zones (from semi-desert to highland).	Precision: prevents "over-insulation" or "under-ventilation" risks specific to the Caspian region.
Institutional Link	Linked to mature EU EPBD digital ecosystems.	Hybrid integration with the Azerbaijan National Certification System (2022).	Continuity: ensures the transition from static "Green Home" certificates to dynamic life-cycle logbooks.
Decarbonization	Focus on operational energy.	Integration of embodied carbon and seismic safety records.	Holistic approach: addresses the specific structural risks and life-cycle footprint of regional building types.

4 CONCLUSIONS

Based on the comprehensive analysis of digital building passports (DBPs) and their regional integration, the key findings and conclusions of this study are structured as follows:

1. Identification of Core Implementation Barriers: The systematic synthesis of European research reveals that while DBP concepts are developing rapidly, their practical implementation remains globally constrained by persistent challenges regarding data availability, interoperability, and active user engagement.

2. Development of a Context-Adapted DBP Model: The main scientific contribution of this work is a newly developed three-level DBP model tailored to Azerbaijan's specific housing stock. Featuring a hierarchical and modular structure, this framework successfully enables the integration of incomplete and heterogeneous data, resolving critical limitations of data-constrained regional environments.

3. Utilization of Standardized Typologies for Renovation: The study introduces a novel direction for optimizing the renovation of mass-series residential districts by highlighting the high potential of template-based DBP solutions derived directly from standardized Soviet-era building typologies.

4. Phased Practical Strategy for Institutional Transition: From a practical perspective, transitioning from Azerbaijan's current conventional energy certification into a dynamic, lifecycle-oriented DBP system requires a phased implementation strategy. This transition necessitates targeted development of local data infrastructure, robust regulatory mechanisms, and deeper stakeholder engagement.

5. Support for Local Sustainable Urban Development: The proposed model serves as a practical technical foundation for regional "Smart Village" initiatives and active urban regeneration projects in Baku, facilitating data-driven planning to successfully meet established energy efficiency targets for 2030.

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6. Infeasibility of Direct Model Transfer: The findings confirm that a direct, unadapted transfer of European DBP models is non-viable. Instead, the most promising pathway forward relies on scalable, hybrid approaches combining standardized data templates with flexible, context-specific renovation strategies.

7. Directions for Future Research: Future academic work should focus on the empirical validation of the proposed model via targeted pilot projects on representative Soviet-era building series, alongside assessing institutional readiness for large-scale deployment and creating standardized data templates.

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