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Uneven cyber risk disclosure across institutions and jurisdictions further complicates assessment and coordination.

Therefore, cyber risk management in digital banking requires not only technological adaptation, but also stronger governance and resilience-oriented regulation.

The digitalization of banking has significantly increased banks' exposure to cyber risks. Data breaches, ransomware, phishing, third-party vulnerabilities, and infrastructure failures represent major threats to banking operations, customer trust, and financial stability.

The analysis shows that cyber risk management in the context of digitalization of banking should be treated as a governance and resilience issue rather than a purely technical one. As banking digitalization deepens, effective cyber risk management will remain essential for secure and sustainable banking development.

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TECHNOLOGICAL EMPOWERMENT AND RISK BOUNDARIES: AN EVALUATION OF DIGITAL APPLICATIONS IN THE UTILITY SECTOR OF URBAN HOUSING

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Annotation. The rapid development of the Internet of Things, big data, and artificial intelligence technologies has accelerated the implementation of smart water meters, smart electricity meters, and smart lock systems in urban housing. These technologies are becoming essential components of smart cities and digital residential infrastructure. The article analyzes the current application of smart devices in urban housing and evaluates their benefits and risks from the perspectives of efficiency, security, user convenience, and governance. The study demonstrates that smart

metering and access systems improve management efficiency, optimize resource use, and increase service transparency. At the same time, they create risks related to data privacy, cybersecurity, digital inequality, and technological dependence. The article argues that sustainable development of smart housing systems requires a balance between technological innovation and legal regulation.

Key words: smart water meter, smart electricity meter, smart lock, urban housing, Internet of Things, digital governance.

1. Introduction

Urban housing management is experiencing rapid digital transformation. Traditional water and electricity meters based on manual reading are gradually being replaced by smart metering systems capable of remote monitoring and automated data transmission. Smart locks and access control systems are also replacing traditional key management mechanisms. These technologies are changing the technological foundation of urban housing and creating new models of interaction between residents, landlords, and service providers.

The expansion of smart housing technologies is closely connected with the broader concept of smart cities. In China, local governments increasingly support the integration of digital infrastructure into residential buildings. Shenzhen introduced the «Action Plan for Accelerating the Promotion and Industrial Development of Whole-House Smart Systems» (2026–2028), encouraging large-scale installation of smart meters and access systems in residential areas [1]. Guangzhou also requires new residential buildings to integrate smart gateways, smart locks, and digital utility systems [2]. These initiatives show that smart housing technologies are shifting from experimental implementation to large-scale deployment.

At the same time, digital transformation generates important social and legal concerns. Smart locks record information about users and access time, while smart meters continuously collect detailed energy consumption data. Such information may reveal residents' behavioral patterns and create risks of surveillance and privacy violations. In addition, remote control functions may allow landlords or operators to disconnect utilities in case of payment disputes, raising ethical and legal questions.

This article analyzes the current application of smart water meters, smart electricity meters, and smart lock systems in urban housing. It evaluates the main benefits and risks associated with these technologies and proposes recommendations for improving digital governance and regulatory mechanisms.

2. Current Application of Smart Housing Technologies

2.1 Global Development Trends

The global market for smart housing equipment has grown rapidly during the last decade. Smart metering systems are increasingly used in apartment buildings, residential complexes, and rental housing. According to Silicon Labs, NextCentury deployed more than 2.8 million smart meters in the United States and Canada by

2025, with approximately 40,000 new apartment units connected monthly [3]. This demonstrates that wireless smart metering technologies have become economically viable for large-scale deployment.

Russia also demonstrates active development of smart housing infrastructure. Rostelecom's «Key» platform operates in more than 6,100 buildings across 335 cities and serves over 1.2 million users [4]. The platform integrates smart intercoms, video surveillance, access control, and smart utility management into a unified digital ecosystem.

In China, the smart home industry is expanding rapidly. Shenzhen hosts more than 300 smart home enterprises, and the local industry scale exceeded 180 billion yuan in 2024 [5]. Smart locks and smart utility meters are now considered among the most practical digital technologies in apartment management systems [6].

2.2 Smart Water and Electricity Meters

The main advantage of smart water and electricity meters is remote monitoring and automated data collection. Two main technological models are currently used.

The first model is based on LoRaWAN wireless local networks. In this system, devices transmit data through local gateways connected to cloud platforms. This approach is suitable for newly constructed residential complexes and centralized apartment systems.

The second model uses NB-IoT technology. Each smart meter contains an independent communication module connected directly to cellular infrastructure. This model is more suitable for decentralized apartment systems and older residential areas [7].

Modern smart meters perform functions beyond simple data collection. Digital management platforms provide real-time information on electricity and water consumption, detect abnormal usage patterns, and generate maintenance alerts. According to research by the U.S. Environmental Protection Agency, smart metering systems can identify water leakage and significantly reduce resource waste.

2.3 Smart Locks and Access Systems

Unlike smart metering systems, smart locks primarily address problems of access management and operational efficiency. Traditional key systems involve high administrative costs, duplication risks, and delays in permission control. Smart locks replace physical keys with digital authorization systems.

Current smart lock technologies include remote password generation, Bluetooth access, temporary permissions, and digital records of all door-opening events. In rental housing, these systems significantly simplify the check-in and check-out process. Apartment operators report that move-in procedures can be reduced from several hours to only a few minutes.

Access control systems are increasingly integrated into broader residential security networks. Shenzhen policies encourage installation of smart surveillance and fire alarm systems connected to digital housing platforms. Consequently, smart access systems are evolving from isolated devices into elements of integrated urban

security infrastructure.

3. Benefit-Risk Analysis

3.1 Efficiency and Cost Reduction

From the perspective of property management, smart technologies significantly improve operational efficiency. Automation reduces labor requirements associated with meter reading, payment collection, and key management.

Under traditional management models, operators managing large apartment portfolios required dedicated personnel for utility monitoring and tenant services. Smart systems reduce manual work and allow managers to supervise larger numbers of housing units more efficiently. Some apartment operators report management cost reductions of 30–50% after implementing digital systems [8].

Smart utility systems also improve financial management. Prepaid models allow tenants to pay before using utilities, improving cash flow and reducing unpaid debts. Automated reminders and remote service control mechanisms help operators manage payments more effectively.

However, these advantages are accompanied by technological dependence. Once operators adopt a specific platform, switching to another provider may become expensive because of incompatible standards and closed data systems. This creates long-term dependence on individual technology suppliers.

3.2 Convenience and User Experience

Smart housing technologies improve transparency and convenience for tenants. Residents can monitor real-time electricity and water consumption, receive digital invoices, and track utility expenses through mobile applications. Such transparency reduces disputes related to billing and resource consumption.

Smart locks also increase flexibility and convenience. Tenants can enter apartments without physical key exchange, while maintenance personnel can receive temporary digital access rights. Digital repair requests and real-time notifications improve communication between tenants and management companies [9].

Nevertheless, technological systems may also create new forms of vulnerability. Equipment failures, software errors, or communication interruptions can disrupt access to housing and utilities. Reports of lock malfunctions, inaccurate meter readings, and delayed technical support demonstrate that technological reliability remains an important challenge.

Moreover, remote disconnection functions may be abused in conflicts between landlords and tenants. In the absence of clear legal safeguards, utility shutdowns may become tools of pressure rather than legitimate management mechanisms.

3.3 Privacy and Cybersecurity Risks

Smart housing systems continuously collect large amounts of personal data. Smart electricity meters record consumption patterns that may reveal residents' daily routines and occupancy schedules. Smart locks store detailed information about access time and user identity.

The legal status of such data remains unclear in many countries. Questions

related to data ownership, third-party access, and commercial use remain insufficiently regulated. Some operators may use collected information for credit evaluation, behavioral analysis, or targeted marketing without explicit user consent.

Cybersecurity threats represent another major concern. Weak encryption, insecure cloud storage, and software vulnerabilities increase the risk of hacking and unauthorized access. If smart lock systems are compromised, physical security may be threatened. Manipulation of utility data may also lead to financial losses and operational disruption.

The Russian experience demonstrates that large-scale smart housing platforms require security standards comparable to financial infrastructure systems. However, many low-cost devices currently available on the market lack advanced security protections.

3.4 Digital Divide and Social Inequality

The expansion of smart technologies may unintentionally increase social inequality. Elderly residents often experience difficulties using smartphone-based systems and digital payment platforms. Although some policies mention age-friendly adaptation measures, many smart housing services remain oriented toward younger users.

Digital inequality also affects low-income groups. Apartment systems requiring smartphone access and online payments may indirectly exclude tenants with limited digital skills or restricted access to technology [10].

Prepaid utility systems may additionally increase financial pressure on households with unstable incomes. Under traditional billing systems, utility payments could be delayed temporarily. Prepaid models shift financial responsibility entirely to residents and may reduce access to essential services.

4. Conclusions and Recommendations

The study demonstrates that smart water meters, smart electricity meters, and smart lock systems provide important economic and managerial benefits for urban housing. These technologies reduce administrative costs, improve resource management, increase transparency, and optimize tenant services.

At the same time, the rapid expansion of smart housing infrastructure generates substantial risks associated with privacy protection, cybersecurity, technological dependence, and social inequality. The distribution of benefits and risks is uneven: management organizations receive efficiency gains, while users often bear privacy and security risks.

To ensure sustainable development of smart housing systems, several measures are necessary.

First, governments should establish clear data governance regulations distinguishing utility data, behavioral data, and biometric information. Sensitive data should be protected under strict legal standards.

Second, industry regulators should promote interoperability and unified technical standards to prevent supplier monopolies and reduce switching costs.

Third, emergency backup systems should remain available. Smart locks should preserve alternative unlocking methods, while manual payment channels should remain accessible for vulnerable populations.

Fourth, mandatory cybersecurity certification should be introduced for smart housing equipment. Security standards should include encryption requirements, regular software updates, and vulnerability disclosure mechanisms.

Future research should focus on comparative analysis of technological models, long-term social impacts of smart housing systems, and empirical evaluation of cybersecurity vulnerabilities.

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