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METHODOLOGICAL ASPECTS OF INTEGRATING ARTIFICIAL INTELLIGENCE INTO THE ENERGY EFFICIENCY MANAGEMENT OF ALGERIA'S HOUSING STOCK

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Abstract
Introduction: In Algeria, the housing sector accounts for a significant portion of the country's energy consumption, making creative solutions essential for improving energy efficiency. Artificial intelligence (AI) offers effective tools to optimize energy use and reduce the ecological footprint. **Purpose of the study:** This study examines the methodological aspects of integrating AI into the energy efficiency management system of Algeria's housing stock. **Methods:** The Six W's approach was employed to analyze AI integration in this context through two steps. First, the theoretical framework was established. Second, a case study was conducted to better understand the context and explore potential solutions from multiple perspectives. **Results:** The findings of AI integration in urban areas fall into two main categories. The first concerns the stakeholders involved, the methods of AI integration, and the spatio-temporal context. The second addresses the motivation and rationale for selecting specific AI integration strategies, as well as the aspects of AI technologies to be adopted.

Keywords: energy efficiency, Algerian housing, artificial intelligence (AI) integration, Six W's approach, smart city.

Introduction

Energy is one of the most important drivers of human progress and economic growth (Türkoğlu and Kardoğan, 2018). As humanity's contribution to climate change and sustainability challenges increases, improving energy efficiency has become urgent, particularly in highly energy-intensive sectors such as housing, which accounts for a major share of overall consumption. Energy efficiency practices and technologies make it possible to maximize the use of energy with minimal waste. This not only reduces dependence on conventional energy sources but also promotes more efficient resource use and helps mitigate greenhouse gas emissions to protect the environment.

Harnessing energy efficiency through artificial intelligence (AI) is increasingly becoming a policy priority in developed countries. AI has the capacity to accelerate progress by enabling faster knowledge generation and advancing technologies for energy conservation and cleaner production. According to Ahmad et al. (2022), AI can enhance the renewable energy sector in several ways, including through the creation of centralized and intelligent control centers, integration of micro-grids, improvements in system reliability and security, market expansion, and incorporation of AI-enabled storage into smart grids. The intersection of AI and smart city development is particularly promising, forming a strong alliance. Evidence shows that AI applications provide a solid foundation for advancing smart urban environments. Within smart cities, one of the key AI roles is to improve energy efficiency (Zamponi and Barbierato, 2022).

In Algeria, the introduction of the Smart City concept marks an important step toward sustainable urban development, yet its practical implementation remains complex and requires significant time and commitment. The Smart City initiative, which is an integral part of Algiers' development vision up to 2035, seeks to address the city's major challenges and transform it into a modern, attractive urban center. Although still in its early stages, this initiative provides a valuable case study in the ongoing evolution of Smart City practices (Aït–Yahia et al., 2019). Currently, there is a growing consensus on AI integration in the housing sector to improve energy efficiency — a critical issue given that residential

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buildings account for nearly 40 % of total energy consumption. Moreover, greenhouse gas emissions from this sector contribute approximately 10 % to the national climate change burden.

Recognizing the importance of optimizing energy consumption, researchers in the fields of energy and housing are increasingly exploring how AI can be applied to monitor and enhance energy efficiency in residential buildings. This perspective motivated us to investigate the issue within the Algerian context, using the Six W's framework — Who, What, Where, When, Why, and How. Such an approach requires not only a comprehensive review of the existing literature but also an analysis based on analogical reasoning specific to the study context.

Methods

The housing sector in Algeria is characterized by high energy consumption (Denker et al., 2014) and associated carbon emissions, leading to environmental degradation and financial pressure on households. Addressing these challenges makes the integration of AI solutions into the sector essential for fostering sustainable development. This paper examines the methodological aspects of incorporating AI into the energy efficiency management system of Algeria's housing stock. It begins with an analysis of energy consumption patterns across the main sectors — industry, transport, and housing — drawing on official reports and documents, with a particular focus on housing. Subsequently, the Six W's approach is applied to provide a structured framework for analyzing the nuances of AI integration (Fig. 1). The framework operates on two levels: the first considers the contextual application of AI for energy efficiency in housing, while the second identifies tailored AI integration solutions for the sector. The rationale for using this approach lies in the limited availability of studies applying such frameworks in comparable contexts. Its implementation therefore represents a significant step forward, offering a theoretical basis for practical approaches that account for infrastructure constraints and propose adaptive solutions.

Case Study Presentation

Algeria, the largest country in Africa and the Arab world, has a population of 44.6 million. Combined with its heavy reliance on fossil fuels, this has raised serious concerns about the sustainability of its energy production and consumption patterns. Such dependence not only accelerates environmental degradation but also creates economic vulnerabilities. To address these challenges, a re-evaluation of earlier energy initiatives was required, leading to the assessment of prospective urban development projects that prioritize energy efficiency and the transition toward clean, sustainable energy systems. Fig. 2 illustrates one such initiative: the development of technology districts in Algeria's new cities. These districts are strategically designed to serve as hubs of innovation, integrating digital infrastructure and advanced technologies to support national sustainable development goals.

The housing sector plays a particularly crucial role in this energy landscape, contributing significantly to both overall energy consumption and CO_2 emissions (Benharkat and Telilani, 2020). In the context of the new city initiative, and specifically within the housing sector, Algeria has introduced measures to develop digital infrastructure and adopt innovative technologies, including AI, to support its goal of increasing renewable energy capacity by 2030. These efforts aim to improve energy efficiency in residential buildings, optimize resource management, and enhance residents' quality of life.

Results and Discussion

Energy Consumption Patterns in Algeria

Energy efficiency directly impacts Algeria's economic and environmental development. According to the 2023 National Energy Report by Algeria's Ministry of Energy, Mines, and Renewable Energies, the country's total energy consumption (including losses) reached 72.2 Mtoe in 2023, representing a 3.2 % increase compared to the previous year. This

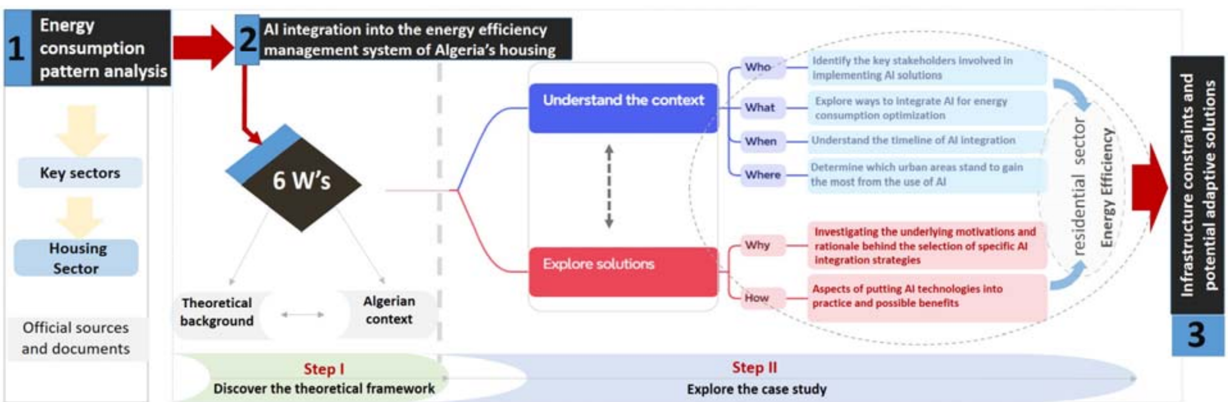

Fig. 1. Overview of the Research Framework and Steps

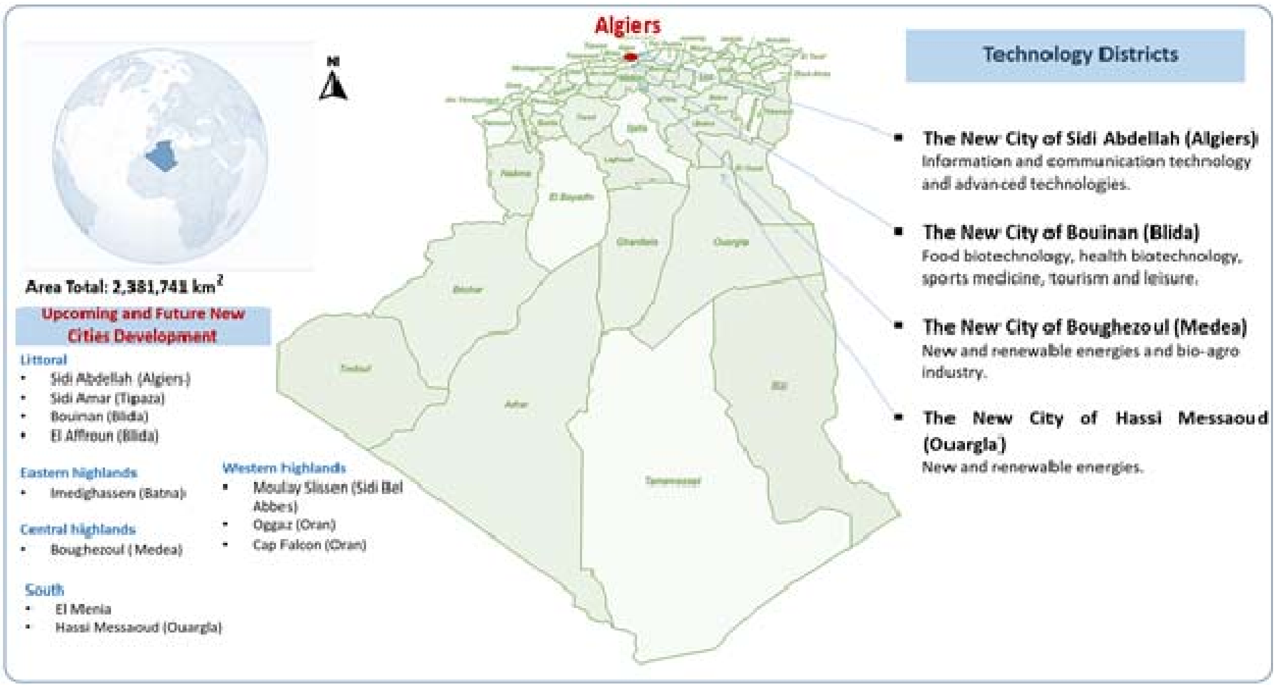

Fig. 2. Technology Districts in Algeria's New Cities (Source: National Territorial Development Plan 2030 and author's interpretation)

growth was primarily driven by final consumption (2.1 %), followed by energy industries (7.1 %), losses (11.5 %), and non-energy industries (2.5 %). As shown in Fig. 3a, natural gas dominates the national energy consumption mix at 39 %, followed by electricity (31 %) and liquid products (22 %). However, renewable energy's share in total final energy consumption remains minimal, as illustrated in Fig. 3b. In 1990, renewable energy accounted for only 0.2 % of consumption, gradually increasing to 0.4 % in 1995. The upward trend continued until it stabilized at 0.4–0.5 % between 2000 and 2005, peaking at 0.6 % in 2005. Thereafter, it gradually declined to 0.3 % by 2010 and fell further to around 0.1 % in 2015, stabilizing at 0.1–0.2 % with minor fluctuations until 2020. These findings indicate that renewable energy has not yet established a significant presence in actual consumption. A large portion of renewable energy produced does not reach end-users efficiently, due to losses during conversion and transmission or limitations in existing infrastructure. Consequently, Algeria continues to rely heavily on fossil fuels as its primary energy source.

Meanwhile, the structure of final energy consumption by sector is dominated by households and others (46 %), followed by transport (30 %) and industry (25 %) (Fig. 3c). As shown in Fig. 3d, energy intensity between 2000 and 2017 displays notable sectoral differences. In early 2005, intensity fell by 18 % in both agriculture and transport and by 16 % in industry, while the services sector remained stable. In contrast, the residential sector experienced a sharp increase of 80 % over this period, averaging approximately 3.6 % per year, particularly since 2010. This rise is mainly due to increased demand for heating and air conditioning and the growing use of electrical appliances.

According to Algeria's first updated annual report to the United Nations Framework Convention on Climate Change in 2023, published by the Ministry of the Environment and Renewable Energy, the residential sector is the largest energy consumer, along with the transport sector. As presented in Table 1, the residential sector comprises approximately 11.5 million housing units. Of these, individual houses account for around 65 %, while collective housing makes up the remaining 35 %. Energy consumption across the three primary energy sources is distributed as follows: 69 % from natural gas, 19 % from electricity, and 13 % from liquefied petroleum gas (LPG). A review of energy consumption data over the period 2007–2017 indicates an approximate increase of 1.38 % per year, equivalent to 15,003 million tons of oil equivalent (Mtoe). If this trend continues, consumption is projected to reach around 25,000 Mtoe by 2030.

The results also indicate that energy efficiency varies according to dwelling typology, urban form, and degree of insulation. Two main patterns are observed: 83 % for moderately insulated houses and 66 % for well-insulated houses. This variation across Algerian cities, combined with differences in urban form, highlights the need to reconsider approaches to energy efficiency management and carbon footprint assessment, emphasizing the importance of more in-depth studies.

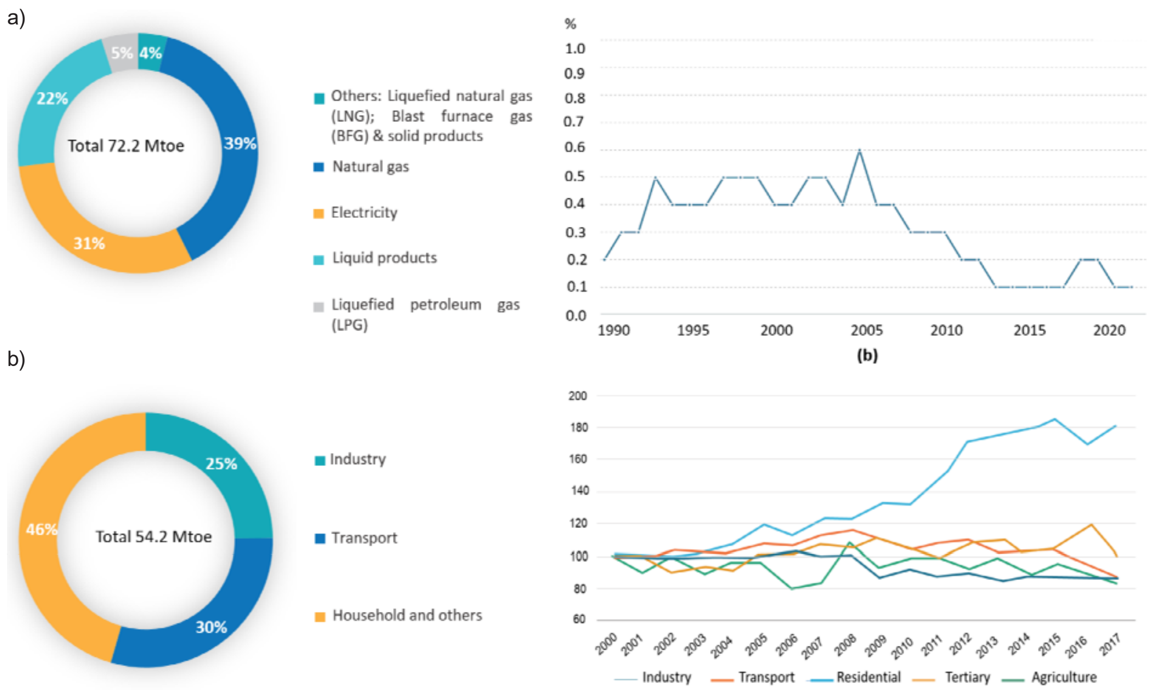

Fig. 3. Patterns and Trends in Energy Consumption across Sectors in Algeria: (a) structure of national energy consumption by energy form, (b) renewable energy consumption (% of total final energy consumption), (c) structure of final energy consumption by sector of activity, (d) evolution of final energy intensity by sector. Source: Redrawn according to the following data: (a, c) National Energy Report (Ministère de l'Energie et des Mines et des Energies Renouvelables, 2023); (b) World Bank (2023); (d) MeetMed (2020)

Table 1. **Patterns of Energy Consumption and Efficiency in the Housing Sector (Source: Algeria's first updated annual report to the United Nations Framework Convention on Climate Change (Ministère de l'Environnement et des Energies Renouvelables, 2023)**

Aspect	Details
Housing stock	Total: 11.5 million units - Individual houses: 65 % - Collective houses (apartments): 35 %
Primary energy sources	Natural gas (69 %), electricity (19 %), LPG (13 %)
Energy consumption growth	- 2007: 10,837 Mtoe - 2017: 15,003 Mtoe (avg. growth: 3.3 %/year) - 2030 (projected): 25,000 Mtoe
GHG emissions	- 2017: 41,487 tons CO_2 equivalent - 2030 (projected): 69,079 tons CO_2 equivalent
Energy consumption per house	- Average: 1.29 Mtoe/year (~15,000 kWh/year) Average permitted consumption - Moderately insulated house: 12,500 kWh/year - Well-insulated house: 10,000 kWh/year
Energy efficiency	- Compared to moderately insulated house: 83 % - Compared to well-insulated house: 66 %

Understanding the Context

Who?

In the development and implementation of AI systems, the involvement of stakeholders at all stages of the design and lifecycle process is crucial. A participatory approach should engage not only those directly affected by the project but also developers, operators, and even passive stakeholders, who must be actively involved in the process (Kunkel et al., 2023).

With regard to habitat energy issues, key actors such as developers and building owners play a decisive role in applying AI to housing projects. Technology companies using AI for environmental sustainability must therefore collaborate closely with these stakeholders to ensure successful project implementation (Kunkel et al., 2023; Yadav and Singh, 2023). The integration of AI into habitat energy management offers clear benefits, including enhanced efficiency and sustainability. However, stakeholders in the energy services industry also bear responsibility for addressing ethical considerations such as data privacy, equitable access to energy, and the environmental impacts of AI-driven solutions.

Academic and research institutions act as key catalysts for applying AI in habitat energy, as they enable the development of environmentally friendly systems that improve energy value chains. The success of such energy management projects depends on several conditions: availability of resources, accountability, technological maturity, expertise, and the capacity for seamless integration (Holecska and Dineva, 2023). Another important factor is financial literacy, which helps stakeholders make informed decisions about the implementation of AI in energy systems (Stecyk and Miciuła, 2023).

The incorporation of AI for energy efficiency depends on several factors: the influence of stakeholders in decision-making, the level of financial commitment, responsibility for ensuring ethical use, the technological maturity needed for seamless integration, and the knowledge and capacity required to effectively manage and optimize AI systems.

In the Algerian context, some studies support AI integration to improve energy efficiency in the residential sector and explain the role of stakeholders, particularly the government. The government's involvement has been crucial in establishing energy efficiency standards, as illustrated by initiatives such as the Eco-Bat program (Sayed et al., 2022).

Table 2 presents our proposal in the form of a stakeholder matrix, showing the different levels of influence, financial commitment, responsibility, technological maturity, and knowledge among the actors involved in integrating AI into Algeria's residential sector. The government and regulatory agencies have strong influence since they set the rules and guidelines that govern how AI is applied in housing. However, variations in financial support and technological expertise may hinder the successful execution of policies. Technology companies, by contrast, are better positioned to drive the adoption of advanced AI solutions. They combine significant financial resources and technological maturity, even if their direct influence is more limited. Non-governmental organizations and energy service providers, although contributing less in terms of finance, influence, and technology, still play an essential role in raising public awareness and advocating for inclusive energy policies. Overall, effective collaboration among all stakeholders — leveraging their diverse capacities — will be critical for the successful integration of AI in Algeria's housing sector.

What?

The application of AI in the energy sector, also referred to as smart energy, aims to reduce its environmental impact by enhancing the efficiency of energy management, production, and consumption (Gil–González, 2022). This is achieved through advanced AI-based management technologies. For example, research in South Africa has demonstrated the potential of AI methods, such as support vector regression (SVR) and artificial neural networks (ANN), to improve electricity access and thereby enhance living standards (Mashapu et al., 2022).

At the same time, in the realm of smart homes, AI plays a crucial role in improving energy efficiency through advanced technologies, including smart meters, which facilitate monitoring of utility usage and regulation of indoor temperature (Rehman et al., 2020). Many countries are increasingly focusing on the housing sector as a major contributor to energy consumption, including Algeria, where research on AI technologies is still in early stages in terms of both study and practical application. For instance, the Intelligent Reasoning Rules for Home Energy Management (IRRHEM) system employs natural resources to inform residents about instances

Table 2. **Proposed Stakeholder Matrix for Enhancing Energy Efficiency in Algerian Residences through AI Integration**

Stakeholder	Level				
	Influence	Financial Engagement	Responsibility	Technological Maturity	Knowledge & Capacity
Government & Regulators	High	Variable	High	Medium	Variable
Technology Companies	Medium	High	Variable	High	High
Building Owners & Developers	Medium	High	High	Medium	Variable
Utilities	Medium	High	Medium	Medium	Medium
Research Institutions	Low	Medium	Low	Medium	High
Energy Service Companies	Low	Medium	Medium	Medium	Medium
Non-Governmental Organizations	Low	Low	Low	Low	Variable

of energy waste and coordinate related activities to achieve efficient electricity consumption (Saba et al., 2022). Additionally, the successful application of energy management techniques for off-grid solar households using artificial neural network algorithms has been demonstrated, enabling energy savings without compromising comfort (Chekired et al., 2019). These AI technologies show significant potential for optimizing energy efficiency in residential settings. Consequently, to identify the most effective solutions, it is necessary to adopt a systematic approach due to the diverse and complex nature of AI applications.

We therefore propose a straightforward four-part model (Fig. 4) to assess the critical elements influencing the success of energy-saving initiatives. The aim of this model is to facilitate well-informed decision-making by providing a structured methodology for evaluating AI initiatives, thereby ensuring a balance between effectiveness and practicality.

Firstly, managing technological development allows stakeholders and leaders to ensure that new technologies are effectively used and sustainable throughout the processes of energy generation, distribution, and consumption. In computer science, task management can be approached at three levels of algorithmic complexity: simple, medium, and complex. Secondly, data utilization refers to the collection, analysis, and application of data to guide strategic decisions and improve energy-related processes. This dimension can be considered at three scales: applications relying primarily on data from individual households or buildings, solutions using data from a broader urban area such as a city, and initiatives leveraging nationwide datasets. The third dimension concerns the degree of complexity associated with implementing the intervention. It evaluates the specific actions required for deployment and considers the necessary resources — financial, human, and time — across different organizational contexts. Three levels of intervention can be defined: low-complexity solutions that are easy to implement and require minimal infrastructure modifications; medium-complexity solutions requiring moderate infrastructure enhancements; and high-complexity solutions demanding substantial infrastructure changes or significant organizational adjustments. The fourth dimension relates to the impact and scope of the intervention, which can manifest across three

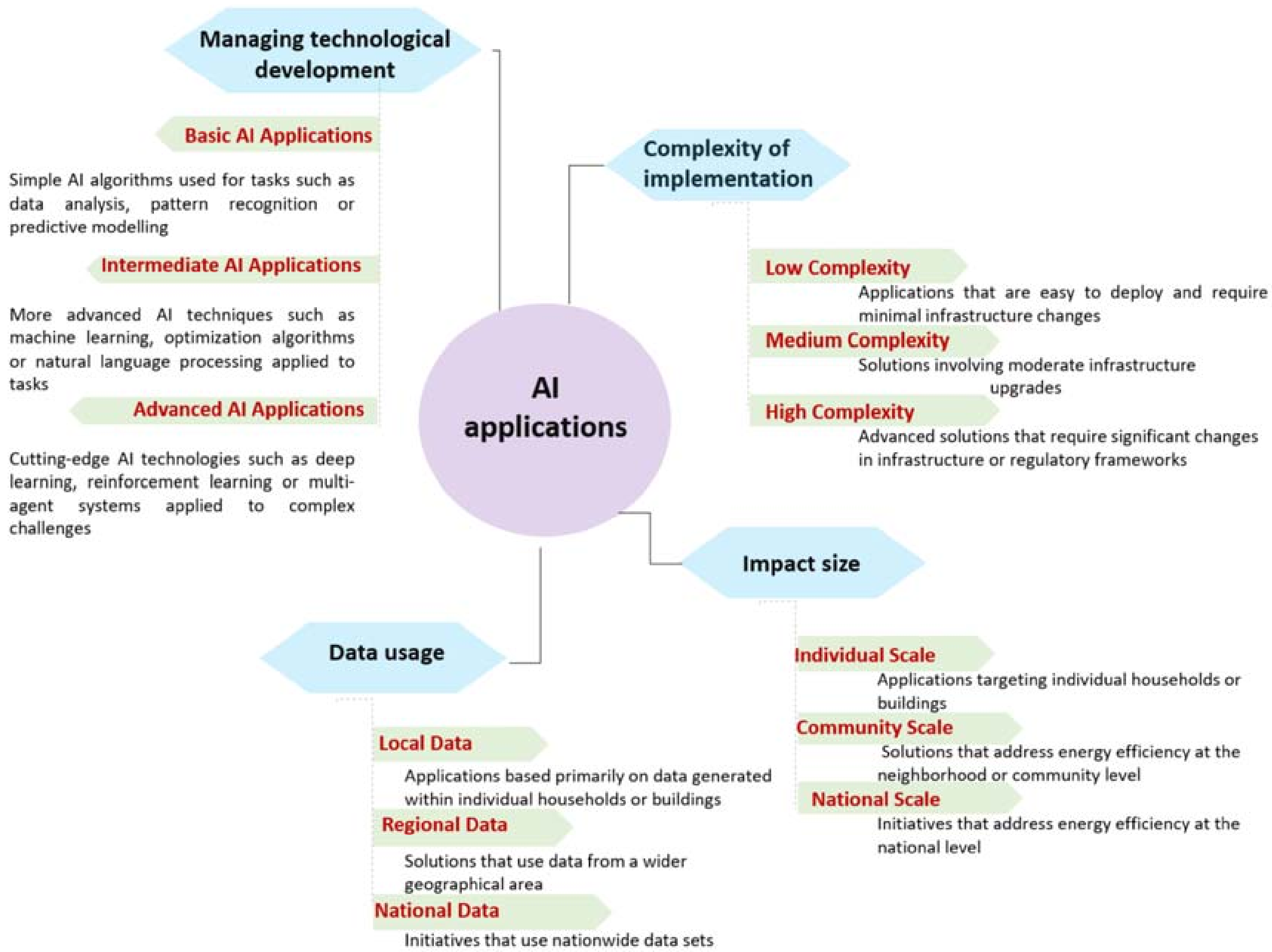

Fig. 4. Proposed Four-Dimensional Model for Integrating AI Applications to Optimize Energy Efficiency in the Algerian Housing Sector

sequential and overlapping scales: individual, city, and national levels, or as part of a general strategy for AI integration in energy management.

When?

The importance of understanding and evaluating progress in integrating AI into residential energy-saving strategies necessitates analyzing current advances and identifying future challenges and opportunities, as research in Algeria highlights that integration initiatives are still in their infancy, primarily in the realm of theoretical research. Initially, researchers focused on using AI to regulate electricity consumption in smart homes (Saba et al., 2022). It is projected that by 2030, Algeria could reduce its energy consumption by 15 %, primarily through improvements in window quality and enhanced thermal insulation (Sotehi et al., 2022). To facilitate this objective, policies such as the Eco–Bat program and revised thermal regulations have been implemented to improve energy efficiency within the construction sector, a significant energy consumer (Meftah and Mahri, 2022). Subsequently, AI algorithms have been deployed in on-grid photovoltaic homes to manage energy consumption effectively, demonstrating the ability to reduce energy usage while maintaining comfort levels (Chekired et al., 2019). Moreover, AI techniques, including artificial neural networks and case-based reasoning systems, have been employed to optimize building energy efficiency, enabling the design of single-family homes with minimal energy consumption (Węglarz, 2018). Furthermore, the integration of AI into the architectural design of low-energy residential buildings in Algerian Saharan conditions has led to significant energy savings, highlighting the importance of both passive and active design strategies (Haddam et al., 2019).

A thorough summary of the evolving use of AI in the housing sector is presented in Fig. 5, with a focus on improving energy efficiency. In the Algerian context, this integration can be divided into four major phases, each reflecting notable advancements and trends:

Prior to 2010: Initial conceptualization and exploration of theoretical frameworks and guiding principles, which laid the foundation for subsequent developments.

2010–2020: Implementation of proof-of-concept trials, allowing preliminary testing of AI-driven solutions. Simultaneously, a series of research initiatives was undertaken to evaluate the practical efficacy of AI.

2020–Present: Stakeholders have collectively worked to integrate AI solutions into established procedures, adopting advanced AI technologies, including machine learning and neural networks, for predictive maintenance, demand response, and energy optimization.

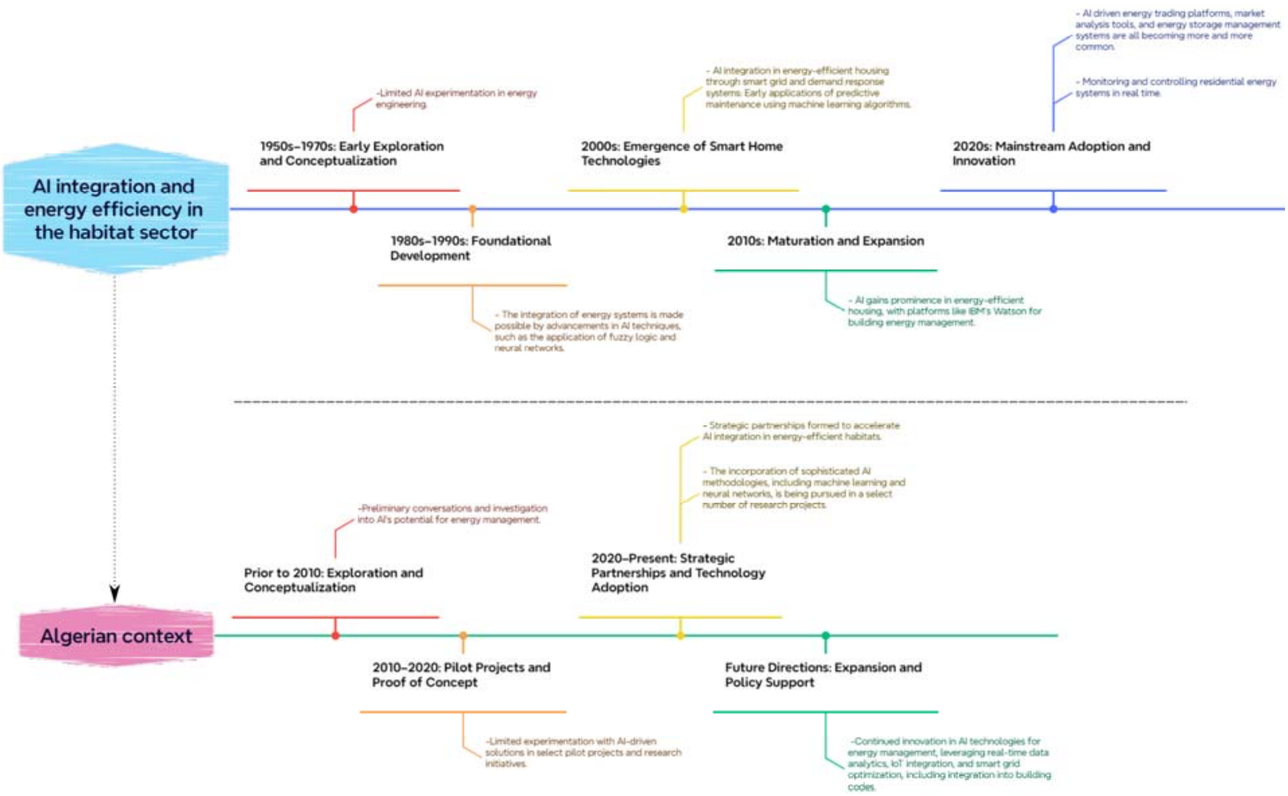

Fig. 5. Chronological Integration of AI for Energy-Efficient Housing: (a) Historical Evolution over Time, (b) Context in Algeria (suggested by the author).

Future Directions: With increasing recognition of AI's potential to support sustainability and climate objectives, there is a growing focus on the transition toward broader acceptance and institutional support for AI-driven energy-efficient housing. It is expected that policymakers and industry leaders will increasingly prioritize comprehensive regulations and guidelines to facilitate the widespread adoption of AI in the residential sector.

Despite these advances, significant challenges remain in the effective deployment of AI for energy management. Implementing new technologies often requires substantial financial resources, particularly when modernizing existing systems. Addressing these challenges will require further research to resolve technological and regulatory issues, with a clear emphasis on prioritizing AI integration in projects highlighted in government agendas.

Where?

The integration of AI technology is becoming increasingly prevalent in urban planning, particularly as a response to the challenges posed by rapid urbanization. This integration is critical for addressing various urban issues, including the need for energy-efficient housing solutions across diverse contexts. AI provides applications for optimizing energy consumption (Sanchez, 2023), identifying resilient and inclusive urban land-use strategies (Koutra and Ioakimidis, 2023), and facilitating efficient urban redevelopment initiatives (Ye et al., 2023).

In Algeria, the use of AI in housing projects involves analyzing specific factors to determine energy demand and consumption patterns. This includes spatial and temporal analyses to identify neighborhoods with high energy use due to factors such as aging infrastructure or operational inefficiencies. Large residential complexes and urban redevelopment projects, particularly in areas undergoing renovation or replacement of old buildings, should be prioritized to ensure compliance with energy efficiency standards and address neighborhoods with diverse income levels. Furthermore, aligning AI interventions with smart city initiatives ensures that AI-driven solutions not only optimize energy consumption in housing but also contribute to broader goals of sustainable urban development.

Exploring Solutions

Why?

The objective of selecting specific solutions for integrating AI into energy-efficient systems is to enhance reliability and generate technological and economic benefits (Danish, 2023). These solutions can contribute to reducing carbon emissions and combating climate change (Navarra, 2023), aiming for integrated building management and effective digital connections with users and smart grids (Mocerino, 2020). In the Algerian context, the use of AI in implementing energy-saving measures in the housing sector is expected to generate significant benefits. As illustrated in Fig. 6, five key benefits can be identified with their reliability and applicability explained:

1) innovation in construction — AI integration may inspire creativity by introducing new technologies for designing more efficient, sustainable, and durable buildings; 2) curbing carbon emissions — AI optimizes energy use and encourages adoption of clean energy sources; 3) enhanced efficiency — continuous monitoring and optimization improve building performance; 4) socio-economic advantages — AI creates new job opportunities, reduces household energy costs, and improves living standards; 5) data-driven decision-making — AI enables stakeholders to identify patterns, forecast energy needs, and implement targeted interventions for maximum impact.

How?

The integration of AI is central to achieving actual energy savings in the residential sector. Agent-based modeling and simulation, when applied to homes operating with hybrid renewable energy systems, can reduce energy usage without compromising occupant comfort. Furthermore, AI can enhance building energy management systems by enabling intelligent heating, ventilation, and air conditioning (HVAC) optimization, as well as predictive energy efficiency measures (Mocerino, 2020). As noted by Szczepaniuk and Szczepaniuk (2023), integrating AI along the energy value chain has the potential

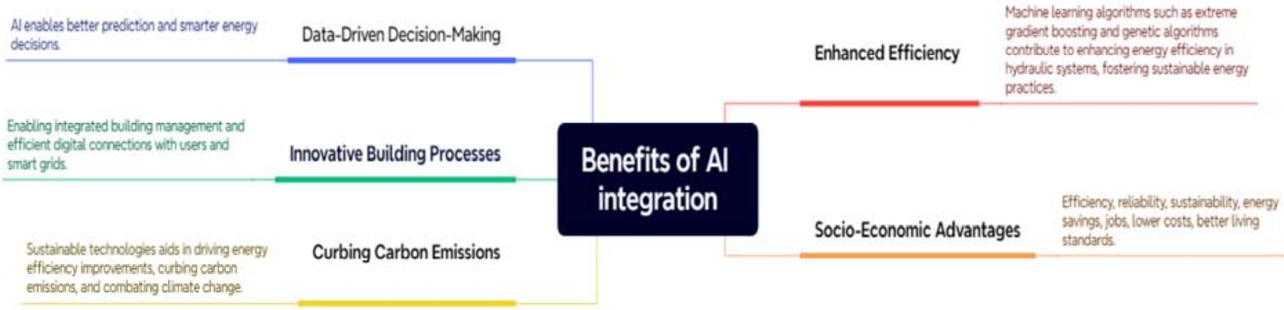

Fig. 6. Key Benefits of AI Integration in the Algerian Residential Sector

to promote sustainable energy practices, improve energy utilization, and reduce overall environmental impact. This can be achieved through techniques such as machine learning, metaheuristic algorithms, and intelligent fuzzy inference systems.

Several studies have identified key factors that facilitate AI integration in residential energy management. These factors can be broadly classified into two categories: those that enable automatic energy management and those that allow the anticipation of system failures, thereby reducing costs. The first category includes smart control systems, while the second encompasses predictive maintenance, machine learning, and data analytics, which collectively support more effective decision-making based on large datasets. Sensor networks and the Internet of Things (IoT) further enhance performance by providing real-time data collection.

To identify potential avenues for change in the Algerian context, we propose a model illustrating the integration of AI in the residential energy sector, as shown in Fig. 7. This model highlights five key factors, along with their associated methods, challenges, and opportunities. Areas of focus include smart grid integration, intelligent control systems, machine learning and data analytics, sensor networks and IoT, and predictive maintenance.

Infrastructure Constraints and Potential Adaptive Solutions

The integration of AI into residential energy management in Algeria demonstrates significant potential to enhance both efficiency and sustainability. However, based on the Six W's framework, several infrastructure challenges must be addressed before this technology can be widely deployed. These challenges can be categorized into technical, economic and environmental, social and legal constraints (see Table 3 for details).

Considering the Six W's framework, allocating resources to AI monetization through four adaptation mechanisms can enable smoother and more efficient integration of AI into Algeria's energy sector:

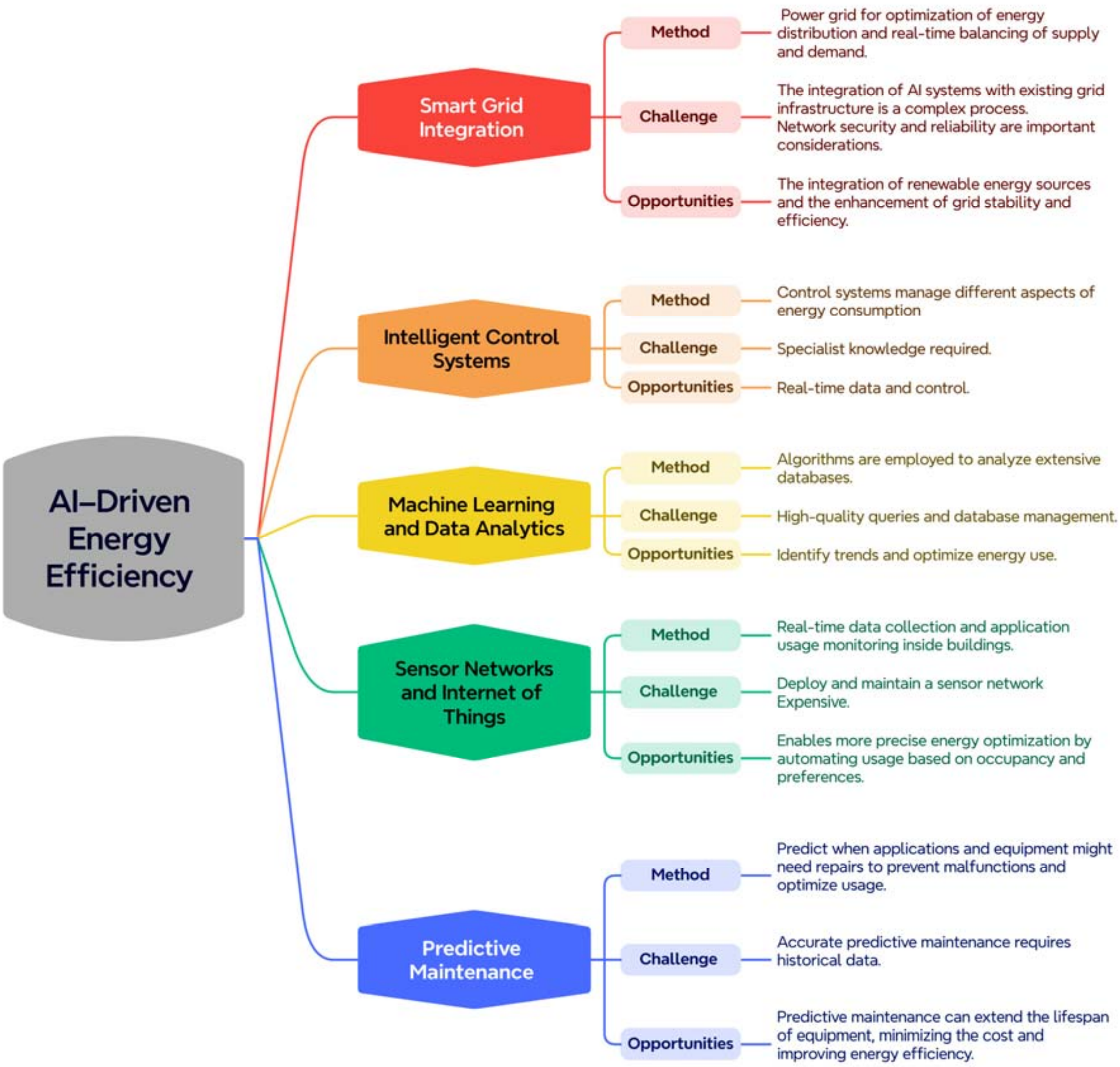

Fig. 7. AI-Driven Energy Efficiency in Algerian Housing: Methods, Challenges, and Prospects (suggested by the author)

Table 3. **Types of Infrastructure Constraints for AI Integration in Algeria**

Constraint Type		Details
Technical	Structure	- Difficulty of integration with traditional energy infrastructure, requiring major modifications. – Significant investments needed to modernize infrastructure and incorporate AI technologies.
	Data and Quality	- Unclear and inconsistent data availability policies hinder accurate analysis and predictions.
	Performance and Scalability	- High computational requirements for real-time data processing, leading to heavy technical resource consumption.
	Experience	- Implementation requires extensive multidisciplinary knowledge.
Economic and Environmental	Cost and Budget	- AI integration involves significant costs. - High costs and complexity of upgrading legacy systems make balancing budgets and AI performance challenging.
	Environmental	- Smart data centers consume large amounts of energy. - Dependence on non-renewable energy sources increases carbon emissions and negatively impacts the environment.
Social and Legal	Social	- Digital divide limits access to smart technologies for some groups, reducing overall efficiency.
	Legal	- Lack of clear policies and regulations for AI in energy management slows down implementation and adoption.

- *Infrastructure and Technology:* A robust digital architecture is needed, including upgrades to communication networks, investments in cloud computing, and enhanced data protection to safeguard sensitive information from cyber-attacks. Moreover, the synergy between AI and IoT enhances precision in data collection and analytics.
- *Policies and Management:* Modernizing laws and institutional frameworks is crucial to regulate the application of AI in governance and establish a clear legal basis for its use in energy management.
- *Skill Development and Training:* Specialized training programs in energy management should be developed to ensure professionals can effectively operate smart tools.
- *Balancing AI and Human Oversight:* AI cannot be entirely relied upon for critical decision-making. Human supervision remains essential to ensure accountability and legitimacy. Mechanisms should be established to review AI outputs and validate operational results, thereby minimizing errors or system failures that could have severe economic consequences.

Conclusion

The present study was conducted with the objective of investigating the potential of integrating artificial intelligence to enhance energy efficiency in Algerian housing. Using the Six W's methodology as a guiding framework, the key findings can be summarized as follows:

Who: A stakeholder matrix has been proposed as a practical instrument for identifying the most influential actors in AI integration, including government and regulators, technology companies, building owners and developers, utilities, research institutions, energy service companies, and non-governmental organizations. The matrix highlights their relative influence, financial commitment, responsibilities, and technological maturity.

What: The study aimed to provide a comprehensive evaluation of the critical factors that determine the success of AI interventions in the housing sector. Four key application areas were identified as particularly significant: the management of technological sophistication, the scope and scale of impact, the utilization of data, and the complexity of implementation.

When: Realizing the potential of AI in the housing sector requires continued research to address the technological and regulatory barriers that currently limit progress. The implementation of advanced technologies — particularly in the context of upgrading existing infrastructure — remains a costly endeavor.

Where: AI integration into the housing sector requires a detailed analysis of energy consumption patterns and the prioritization of large residential complexes and urban redevelopment projects. Neighborhoods with diverse income levels, aligned with broader smart city initiatives, represent an ideal context for AI deployment since such integration not only optimizes energy consumption but also contributes to sustainable urban development goals.

Why: The motivations driving AI integration encompass environmental sustainability, resource optimization, regulatory compliance, cost efficiency, technological innovation, and positive societal impacts, which include improved public perception, enhanced health and well-being.

How: The identification of prospective alterations within the case study context requires an assessment of a number of factors, including: intelligent control systems, predictive maintenance, machine learning, data analytics, sensor networks, IoT integration, and smart grid integration.

Although this research topic has not been extensively explored, particularly within the case study context, the methodology employed herein represents an initial investigation that will facilitate future research by enabling a more comprehensive examination of each dimension. Moreover, the findings of this research will be invaluable for future studies, providing the basis for developing a comprehensive evaluation framework to assess potential AI integration for enhancing energy efficiency. It is envisaged that this framework could subsequently be applied to the development of future smart cities in Algeria.

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МЕТОДОЛОГИЧЕСКИЕ АСПЕКТЫ ИНТЕГРАЦИИ ИСКУССТВЕННОГО ИНТЕЛЛЕКТА В СИСТЕМУ УПРАВЛЕНИЯ ЭНЕРГОЭФФЕКТИВНОСТЬЮ ЖИЛОГО ФОНДА АЛЖИРА

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Аннотация
Введение: жилищный сектор Алжира потребляет существенную часть энергии страны, вследствие чего становится необходимым поиск креативных решений для повышения энергоэффективности. Искусственный интеллект (ИИ) предлагает эффективные инструменты оптимизации потребления энергии и снижения экологического следа. **Цель исследования:** настоящее исследование направлено на изучение методологических аспектов интеграции ИИ в систему управления энергоэффективностью жилого фонда Алжира. **Методы:** для анализа интеграции ИИ был использован подход 6W, реализованный в два этапа. На первом этапе формировалась теоретическая основа. На втором — проводилось исследование конкретного кейса, позволяющее глубже понять контекст и проанализировать возможные решения с разных точек зрения. **Результаты:** результаты исследования разделены на две основные категории. Первая касается участников процесса, методов интеграции ИИ и пространственно-временного контекста. Вторая охватывает мотивацию и причины выбора конкретных стратегий интеграции ИИ, а также аспекты технологий ИИ, подлежащих внедрению.

Ключевые слова: энергоэффективность, жилищный фонд Алжира, интеграция искусственного интеллекта, подход 6W, умный город.