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To cite this article: A P Pomè *et al* 2023 *IOP Conf. Ser.: Earth Environ. Sci.* **1176** 012031

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Is Digitalization Worth the Hassle? Two cases of Innovation Building Operation and Maintenance

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Abstract. The spectrum of innovation in the Architecture-Engineering-Construction-Operation (AECO) industry is called PropTech (abbreviation for Property-Technology). PropTech uses digital technologies to improve the products and processes of the construction and real estate industry over the whole building life cycle. However, PropTech applications are not extensively adopted yet, as many established companies are still doubtful about the added value of a digital transition, which encompasses significant investments. This reluctance might be due to a lack of evidence about the benefits of technology adoption. Therefore, the present study aims to outline the advantages of adopting digital technology in building management by analysing two case studies that can be considered good practices of an effective investment made possible by PropTech. Netix Controls developed a centralized system based on Machine Learning (ML), to collect and integrate data from different manufacturer chillers, fire alarms, and lighting systems, and applied it to two separate networks of 77 and 14 buildings, respectively, which correspond to the two cases under analysis in this paper. Through desktop data and interviews the study analyses economic costs, environmental impact, and users' well-being of the two cases and compares them ideally to a fictional case, which does not include ML but only traditional Facility Management (FM) procedures. In conclusion, the advantages of embracing innovation in FM through digital technologies are outlined. In particular, the potential will be discussed of predictive maintenance, and the prospective implications of real-time building management expanded at district and city scale.

1. Introduction

The digital innovation, that is investing the Architecture-Engineering-Construction-Operation (AECO) industry, is principally adopted in the Operational & Maintenance phase (O&M) of the building life cycle with the objective to reduce costs, minimize environmental impact, and improve users' well-being. In order to demonstrate the advantages in the digital technologies' adoption, this paper analyses the correlation between the adoption of digital technologies and the minimization of buildings' environmental impact, the optimization of operational costs, and the maximization of users' well-being. While the comparison of two real case study projects, this paper attempts to highlight the advantages and the issues in the adoption of technologies in the Facility, Property, Asset management within the framework of Corporate Real Estate discipline.



1.1. PropTech: the digital innovation of the AECO industry

By transforming every sector, digital technologies are becoming indispensable to the survival of businesses. Digital technologies are efficiently and successfully moving the economy to a digital future [1], and pushing a change also in a conservative sector as the real estate [2]. The application of digitalization into the real estate sector goes under the name of “PropTech”. PropTech, crisis of Property and Technology, is a recent narrative in the real estate field. The academic interest on this topic has intensified since 2018, when Scopus registered the first publication that can be found through the keyword “PropTech”. As of today, when searching for the word “PropTech” on Scopus, the largest database of scientific documents with fast indexing process and recent publications’ availability, 40 documents appear, which use the word “PropTech” either as a keyword (21 out of 40) or in the title of body of the text. Even if the academic debate is globally growing by including contributions from USA, South America, Europe, middle East, and Asia, it is not yet representative of the PropTech phenomenon. Few articles contrate on the large-scale interpretation of the PropTech phenomenon [such as, 3]. In the recent years, the debate shifted attention from the interpretation of the phenomenon towards the further possible developments and applications of PropTech solutions. Some articles focus on the implications of the use of PropTech solutions to improve the transparency and standardization of the real estate processes [4,5]. Others look at specific technological applications in the real estate sector, such the use of Artificial Intelligence in the rental platforms [6] or the application of Blockchain to implement smart contracts in real estate [7]. On the other hand, the real estate market is well accepting this word for describing all the technologies applied in the real estate and construction sector (e.g., [8], [9]). The non-scientific debate is expanding on a global scale, with an ever-greater involvement not only of the directly involved real estate market, but also of external entities interested in understanding the scope and transversal implications of the radical transformation that the world of real estate has been facing in recent years. For example, more and more articles on Unissu [10] have been published expressing the meaning of PropTech and its development in different national markets. However, the analyses of the scientific documents make evident two different ways through which authors describe “PropTech”. First, PropTech is seen as a supporting tool (such as, methods or techniques to help the real estate sector) [11] This statement highlights that technology may improve work’s efficiency and effectiveness [1]. Second, PropTech is seen as an approach that can change the property development process [2]. This statement underlines that innovation is applied in the process, product, service, management, and business models [1]. More generally, in 2019 [12] pointed out that PropTech is one small part of the digital transformation of the property industry, affecting the real estate regarding technology-driven innovation in design, data assembly, and transactions. Thus, PropTech integrates cutting-edge technologies to provide innovative services and improve operations [13]. Even if digitalization in the real estate is moving very slowly, many benefits may be identified in the technology application [14]. PropTech solutions are optimizing brokerage services using Internet and smartphones, valuation activities adopting big data and artificial intelligence, and buying-selling-rental platforms [13]. The digital evolution of the recent years pushed not only cities to become smart, but also spaces and buildings [15]. The main benefits go into solutions that offer user services, manage relationships between owner, users, and investors, design and monitor buildings, and optimize the sustainable performance of in-use buildings [14]. PropTech is implementing emerging technologies, such as home matching tools, drones, virtual and augmented reality, building information modelling and digital twin, artificial intelligence (AI) and Internet of Things (IoT). All these technologies have the potential to improve productivity and competitiveness, optimize energy and resources’ utilizations, and reduce the environmental impact of buildings [16]. In this context, PropTech solutions seem to bring sustainable improvements in real estate. Digital technologies are helping to reduce the environmental impact of the AECO industry.

AECO plays a central role in reducing environmental degradation, as buildings are responsible for around one-third of the energy consumed globally and 40% of the emitted greenhouse gas [17]. With the objective to make Europe the first neutral continent by 2050 [18], the European Union is pushing all the economic segments toward sustainability. However, the European building stock is far from being sustainable, as only 25% of the built environment complies with the current standards [17]. Thus, the market is asking the AECO industry to always increase its productivity, quality, and service levels with the aim to integrate smartness, sustainability, and inclusiveness [18]. Digital technology may help the

real estate and construction sectors to make buildings more sustainable. According to Isobel Lee [19], real estate reporter and editor, PropTech “is the latest weapon in the real estate industry’s fight to be more sustainable”. The introduction of digital technology would contribute tools for reducing the environmental impact of buildings. The concept of Smart Sustainable Buildings emerges in the European Directives with the aim to highlight how buildings may adapt according to external inputs, coming both from users and external conditions, such as weather [20]. These buildings, that use renewable energy, are managed through the adoption of digital technologies that provide smart management [21]. In this contest, the Operational and Maintenance (O&M) phase has been identified as the highest consumer of resources (materials, energy, and costs) among all the phases of a building’s life cycle. The literature highlights that the development of information technology, especially through the adoption of artificial intelligence and big data management, allows for an optimized decision-making process [13]. Thus, the need to optimize sustainable performance of buildings during the O&M phase encourages building managers to adopt digital tools and improve existing building management systems (BMS) [22]. BMS is used to monitor and control all the mechanical and electrical component and computer-based systems of buildings [23]. The high level of energy use in the AECO industry has driven the need to decrease consumption by adding to BMS amplified sensor data and improved computational support [24]. Chen et al. [25] confirm that an efficient facility maintenance and management system enables to sustain buildings more effectively. Consequently, building maintenance has enlarged its relevance in the recent decades, mainly because of the increased sophistication of buildings [26]. As maintenance is a core activity to reduce operational costs, the planning phase of maintenance has become increasingly relevant [27]. Facility managers have started to integrate new technologies, such as dynamically adaptive systems for self-maintenance and machine monitoring [27]. Nevertheless, digital technology integration in real estate operation is still slow. A study conducted in 2017 [28] reported that even if real estate companies agreed in adopting technologies for improving operation’s efficiency, only few of them were currently investing in PropTech. Moreover, a longitudinal study conducted by the Italian PropTech Network of Politecnico di Milano since 2018 shows that the reluctance of real estate “traditional” companies in adopting digital technologies was very high in 2018. The hesitancy seems to be slowly decreasing as the adoption of PropTech solutions has eventually started to prove positive impacts on the business [29]. In effect, evidence is still weak of how the innovation introduced by PropTech solutions is helping to solve specific issues of the real estate sector, such as the environmental impact of the built environment, the integration of users’ well-being in the facility management, and the optimization of operational costs [30]. To the knowledge of the authors, the scientific literature on “PropTech” is still missing a review of the benefits that digital technologies are bringing to the O&M phase of buildings’ life cycle. Therefore, the present study aims to outline the advantages of adopting digital technologies in building management.

2. Methodology

Technologies are spreading across the AECO industry, which accelerates the adoption of digital strategies. Digitalisation is modifying the way AECO operators plan, deliver, operate, maintain, and manage the built environment. With the objective to highlight what concrete benefits the adoption of certain technologies entails in the O&M phase of a building’s lifecycle, the present study looks at a case study company by investigating economic costs, environmental impacts, and users’ well-being that are obtained through innovative technology integration of BMS and AI.

The case-study company, namely Netix Controls, has been chosen as an international company operating in Middle East, Europe, and America, and as a best practice in adopting digital technologies for optimizing building management. Moreover, Netix Controls is testing BMS and AI together since 2018 with the objective to overcome the traditional BMS with an “intelligent”-BMS. This allowed the company to collect several data, that helped to improve the measurement and the control of buildings’ systems and components over time.

First, a desktop analysis of the company throughout its website and of some reports of real applications has been conducted. Second, in order to demonstrate the real benefits of the adoption of an integrated approach for the building management, a second step of analysis is conducted by comparing two projects. Netix Controls uses to ask clients to fill a survey for managing the improvements brought

by the project. Netix Controls collects data about operational cost (manpower and contract costs), energy expenditures, time to solve failures, and avoided failure of critical components. So, the authors have analysed the last two projects conducted by Netix Control in the end of 2021, both located in UAE. Netix Controls provided to the authors the datasheets of the two projects in order to make a comparison. The two projects have been selected because they are similar in their objective and they represent the latest work conducted and evaluated by Netix Controls. Finally, to deeply understand the platform functioning and its impact on the business, the authors conducted a focus group with three company representatives, namely the Europe Business Development Director, the Director – Technical & Operations (Europe), and the Chief Technology Officer. The State of the Art analysis and the desktop analysis on the last projects evaluated by Netix Controls allowed the authors to define specific questions to open the discussion. The focus group was conducted in May 2022 on Microsoft Teams. The discussion touched the following points: (1) how Netix Controls is introducing buildings' predictive maintenance, (2) which future implementations are expected to improve building management, and (3) which are the implication on cities of the use of such technological framework. Finally, the paper reports conclusions, in which future trends of digital technologies in AECO industry are reported.

3. Case studies analysis

The case study company, named Netix Controls¹, has the general objective of leveraging technology in the building management throughout the introduction of innovative and sustainable solutions. Netix Controls, founded in 2016, is located in Schiphol-Rijk, Netherlands, and part of the Sanjeev Bhatia Group. The company commercializes a network of technologies based on Internet of Things (IoT) and Artificial Intelligence (AI) by adopting a proprietary framework (called Niagara Framework) for facility and building management.



Figure 1. Scheme of the Management System “Konnect” implemented by Netix Controls – retrieved by Netix Control report “Intelligent integrated command & control centre”, 2022.

Firstly, the authors have analysed the technology adopted by the company on several projects all around the world. This analysis has been fundamental in order to identify the technological network behind the intelligent management system developed by the company. Netix Controls has analysed and adopted in the international market (such as, USA, Finland and United Arab Emirate – UAE) the traditional BMS for years to implement a new software, called Konnect, an AI powered platform that allows energy analytics, remote connectivity, and predictive maintenance. With its studies, Netix Controls surpasses the traditional BMS by providing real-time alerts, an overview of the entire facility

¹ Accessible from: <https://www.netixglobal.com/>

analysed, and the integration with third party devices. Any existing BMS infrastructure can be linked to Konnect according to the “Android Approach” which makes this product exceptionally adaptable. This empowers end-users with an intuitive system, avoids major cost for replacements, and remotely connects buildings. Konnect is a full-featured, cloud-based asset and energy management software, designed to increase reliability, efficiency, and sustainability of buildings (see **Figure 1**).

The Netix Konnect platform is designed to integrate, analyse, control, and optimize the built environment by reducing human interface, implementing machine learning and digital control, and introducing AI. The Konnect platform can manage several issues of building management, such as Workplace Management, Maintenance Management, Inventory Management, Helpdesk Management (open – operate – close tickets), Vendor Contract Management, and Safety Plan. The integration and simultaneously management of these issues can optimize buildings’ efficiency. As reported in **Figure 2**, the application of Netix Controls integrates together four tasks, that usually are conducted separately: building performance management, remote enterprise BMS, fault diagnostics and analytics, facility and property management. This integrated approach helps improve the building management by combining services that are usually thought and managed separately. Finally, the building management brings the operations to a smarter environment that transforms the building into an intelligent one without disrupting the technological system already implemented, but rather integrating it.

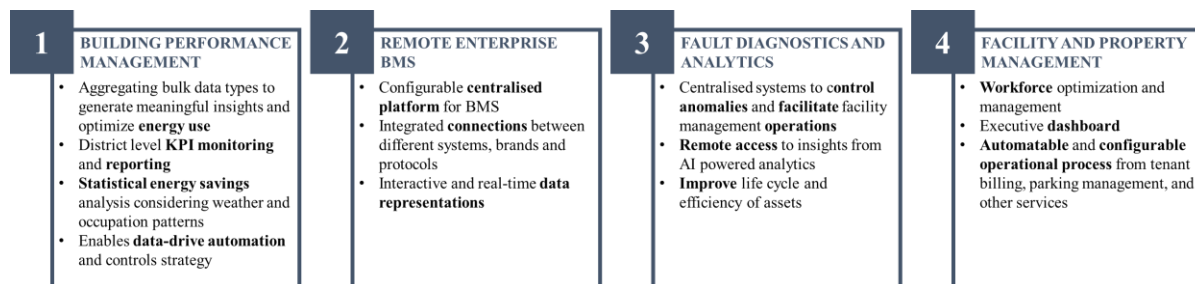


Figure 2. Scheme of the control process used by Netix Control for managing buildings – elaboration of the authors.

From the desktop analysis of previous evaluations conducted by Netix Controls, the company is expected to obtain for each project a manpower and contract saving of 65%, an energy saving of 16%, and a time saving of critical breakdowns of 80%. These savings have been defined by the comparison of previous projects that implement the integrated building management approach, proposed by Konnect.

3.1. Projects’ comparison

The authors compared the benefits reported by the building management groups of two different projects that moved from a traditional building management to a digital one by adopting Konnect. Generally, both the facility management groups reported that the traditional building management system underperformed the building operation, causing waste of energy, increase of costs, and uncomfortable environments for users due to the breakdown of critical building components and long-time of maintenance. Thus, the analysis of two projects (**Table 1**) that implement live data systems, provided by Netix Controls, is reported below to demonstrate the benefits in energy and cost savings, and in adapting assets to users’ preferences and needs by taking actions in real time.

Project 1 consists of connecting chillers in 77 buildings to control energy and asset management. These buildings are commercial units located in the UAE and include more than twenty thousand I/O points (i.e., modules that connect the input and output field devices). The main issue of Project 1 is to integrate different manufacturer chillers. The customer aims to optimize the energy management as more than 50% of annual electricity consumption of those 77 buildings was attributable to chillers.

Project 2 consists of integrating 14 buildings to a Central Server to efficiently monitor, control, and schedule chillers. Buildings are in the UAE and include more than fourteen-thousands of I/O Points. The challenge of Project 4 is to implement a solution without integrating any new device in buildings.

The implemented system discovers parameters, maps, and exposes data in a unified manner, generates different levels of alarms, and reports information about maintenance.

Table 1. Comparison of the two projects – elaboration of the authors on Netix Controls post evaluation reports.

	Project 1	Project 2
Object	77 commercial buildings	14 commercial buildings
Location	UAE	UAE
Pain point	50% of annual electricity consumption is attributable to chillers.	Monitor, control, and schedule all the existing controlling devices of chillers, fire alarms, and lighting system in a manual and disconnected way.
# I/O points	20.000+	14.000+
Aim	Minimization of energy consumption.	Monitor, control, and schedule all the existing controlling devices of chillers, fire alarms, and lighting system in a planned and automatic manner.
Solution	Netix Controls worked on developing an intelligent controller to extract data from chillers and unify them in a centralized and online platform. The online platform controls chillers real time by setting operational parameters (such as, temperature and humidity) according to the outside climate, and by learning the users' preference over time.	Netix Controls developed a centralized system to collect and integrate data from different manufacturer chillers, fire alarms, and lighting systems of 14 buildings. The centralized platform maps the BMS equipment points, generate different levels of alarm and mailing to inform simultaneously technicians and facility managers, and define a complete system validation based on ML. Moreover, Konnect implements automatically a chiller operating log, which, recording all the operating parameters, is able to identify critical issues of the system and prevent it from failures.
Technology integrated	Konnect as an "intelligent"-BMS: IoT sensors – AI – ML – online platform	Konnect as an "intelligent"-BMS: IoT sensors – AI – ML – online platform
Impact	Energy management optimization.	Online, shared, and well-organized maintenance operation logs of all systems.
Energy savings	The track of chillers' operations from the platforms allows to control remotely and digitally the change in temperature according to the external climate.	The more reliable maintenance management improve the operation of HVCA, lighting, and fire systems of the 14 buildings. This reduces energy consumption in 1 year of operation by 15%.
Cost savings	The track of chillers' performance helped facility managers understand the causes of operational logs. This allows a better plan of maintenance activities, as the online platform started providing suggestions for improving efficiency and effectiveness. Moreover, the digital control of setting operational parameters allowed to reduce costs.	The centralized controlling dashboard enabled a better, faster, and more reliable maintenance management, reducing the cost of operation by 20% in 1 year of operation.
User wellbeing	Adaptation of indoor environmental parameters based of real-time monitoring of outdoor weather conditions Monitoring of user behaviour Integration of user preferences	Ability to identify the critical buildings' components and prevent failures of those components that are critical for the users' activities performed in the buildings

The analysis firstly allows to understand the adaptability of the Netix Controls system. From the screening of the solutions of the two projects (see **Table 1**), adaptability emerges in all projects. Netix Controls worked on an intelligent controller platform that were able to collect and analyse data from different BMS pre-installed in the technical systems of buildings. Especially, in project 2, Netix Controls worked on the existing controlling devices without integrating any new sensors in the buildings.

Secondly, Netix Controls not only worked on an adaptable framework, but also introduced adaptability into the buildings, which started looking at users' preferences and needs and change real-time according to external conditions, like climate. On one hand, in Project 1 Netix Controls developed an online system that integrates the weather forecast and users' behaviours in order to set indoor environmental parameters of the buildings that look at the preferences of users. On the other, in Project

2 the implemented platform can identify the critical buildings' components and prevent failures of those components that are critical for the users' activities performed in the buildings.

Third, Netix Controls works also on the process of building management. For example, in Project 2 the application of Konnect improved the maintenance process of chillers by developing the chiller operating log in which the system is able to record all the operating parameters. This is a valuable diagnostic tool useful for the maintenance workers, and it is the base to define trends in the performance.

Finally, it allows to identify four main benefits that projects report, using the customized systems:

1. Energy management: all the systems host state-of-the-art energy monitoring dashboard, that provides real-time information, comparisons among different year, and a set of KPIs to control consumption.
2. Return on investments: all the projects see a return on the investment due to the decrease in manhours for maintaining the asset, asset breakdown and repair (replacement costs), energy consumption, and users' feedbacks. Moreover, the two projects show a decrease of about 75% in the man-hours per year even if the number of alarms per day remains the same; as well as a decrease of around 15% of energy costs.
3. Resource Optimization and Asset Management: all the systems allow to convert anomalies into service tickets for technicians who resolve and return the close-out status back to the system. This helps to avoid human error and ensure the satisfaction of user needs.
4. Detailed real time fault detection and diagnosis: all the systems can improve reliability, availability, maintainability, and safety of equipment thanks to the continuous data monitoring and the analysis of anomalies.

3.2. Focus groups with the company

The focus group confirms and complements the results reported from the desktop analysis of the two projects.

First, the participants in the focus group showed the easiness of use for the operators and advantages of Konnect, which displays online the controlling dashboards. Both the controlling platforms of the two projects have been divided in a "management" section and a "reporting" one. In the first, building managers can set the parameters of the buildings' components; while in the second, building managers can control the results, that look at the energy performance, the maintenance performance, and the indoor environmental quality.

Second, the concept of predictive maintenance was discussed. The systems implemented for the two analysed projects learn how to maintain the building. Konnect adds a building performance management system composed of AI and ML technologies, which receives data from the IoT sensors set in the buildings. Then, this system is integrated with a fault diagnostic and analytics platform that guides the facility and property management and act directly on the IoT sensors. Therefore, the interviewees reported that Konnect does not only collect and report information, but, knowing time, location, costs, and activities performed, it starts to predict how many times, when, and how a maintenance activity needs to be performed. Indeed, the system understands the use of different areas, such as parks, squares, or pools, and predicts maintenance activities or future implementation for answering users' needs. In the words of the interviewees, Konnect literally "gives voice to the buildings".

Third, another point of interest is the implementation of Digital Twin technology as a further advancement of the system already in place. This technology, by transforming IoT into an interconnected digital object that works as a whole, would support the information exchange among different operators, and the collection of data of the entire building lifecycle. In this study, we did not analyse deeply this concept, however for an academic purpose the point of view of the company on Digital Twin is relevant. Indeed, the application of the "intelligent"-BMS and the online platform, developed by integrating AI, ML, and IoT, allows the potential implementation of Digital Twin technology. The interviewees confirmed the willingness to integrate Digital Twin and their belief that the Konnect platform can be used for larger environments, such as cities and wider territories. The platform, used by a large real estate developer company for monitoring 100 plus vertical buildings together, may connect thousands of buildings and infrastructures. The scale of Project 2 already shows the potential of this platform to expand into a multiple-building management system, which will help to

optimize cities by introducing concepts of Smart Cities. Such an application could support policy makers on different scales in managing a wide range of issues from the control of swimming pool conditions to waste management, fire risk detection, and energy consumption monitoring.

4. Discussion and conclusions

The study makes evident that multiple technologies can be adopted in the AECO industry. Among these, BMS with the integration of additional technologies, such as IoT, AI, and Machine Learning may have a crucial role in optimizing the sustainable performance of buildings during the O&M phase.

The case of Netix Controls showed the capacity of such systems to reduce the energy used, to increase cost savings, and to adapt the assets to users' preferences and needs by taking actions in real time. This company has developed a very adaptable system that is still learning and evolving. The system, starting from the analysis of maintenance activities, now can also manage energy, waste, and utilization. One of the most promising outcomes of this set of technologies lays in the implementation of a predictive maintenance. The predictive maintenance, reachable just through technology, is able to avoid human mistakes. By showing the relation between technology and sustainability, Netix Controls is a good example of PropTech solution. Its system optimizes costs, reduces consumption, and improve users' well-being through "listening" to the built environment. However, the cost savings mostly depend on less workers needed for performing activities. On the other hand, more specialized employees are needed in order to use correctly the system and assist in case of problem with the platform. This is a risk that the real estate industry must be faced.

This study represent a first analysis of the benefits in adopting digital technologies in building management. Even if the improved efficiency in building management is well represented in the discussion, the return of the investment is still an open question. The present study could not compare the upfront investment of implementing Konnect with the cost savings produced by the "intelligent"-BMS. This is a critical issue especially for those buildings that haven't a traditional BMS already installed and need a full reconvention from a traditional asset to a digital one. So, future developments are needed in order to evaluate the magnitude of the technological applications. A question that still needs to be answered is "which are the return of the investment and the sustainable performance of such digital building management systems?". To understand the real magnitude of this relation, a further study among several companies needs to be conducted. Future developments will compare a sample of PropTech companies located in different countries to highlight experiences and possible developments. Finally, what emerges, especially from the discussion, is the possible implementation of Digital Twin into this system. Even if the present study does not focus on this particular technology, the integration of Digital Twin may create a living simulation model that can learn and update from multiple sources and predict current and future conditions of equipment. This will serve the purpose to change completely the way the O&M phase of the building lifecycle is conceived and managed, to transform the AECO industry, and finally make our cities more environmentally sustainable.

Acknowledgments

The authors would like to thank Fabio Lamberti, Europe Business Development Director at Netix Global, and Dustine Stanley, Director – Technical & Operations (Europe) and Chief Technology Officer of Netix Konnect AI for the collaboration for the support.

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