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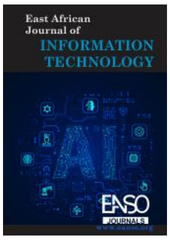

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Original Article

Energy-Efficient Buildings for Biosphere's Sustainability

Dr. Nicodemus Aketch Ishmael, PhD[1] & Dr. Charles Omoga, PhD[2]*

[1] The Catholic University of Eastern Africa, P. O. Box 62157-00200, Nairobi, Kenya.
[2] Alupe University, P. O. Box 845, Busia- Kenya.
* Author's ORCID ID: https://orcid.or/0009-0004-4468-9310; Email: ishmaelna@gmail.com

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ABSTRACT

For decades now, the planet's biosphere sustainability has been at stake due to human, social, economic and environmental factors that have negatively impacted our earth. With global warming and greenhouse gas emissions on the rise, there is every need to worry. Climate change today has a significant impact on almost every aspect of our environment, economies, societies and the planet's biosphere which is under immense threat of extinction. The building sector is a key contributor to carbon dioxide emissions in the world today. Reducing the building sector's production of greenhouse gasses and other negative impacts to safer levels is a big challenge today and it must be met quickly and decisively. Luckily, there are many Information and Communications Technology (ICT) technologies that already exist to mitigate carbon dioxide emissions and adverse climatic change effects. The purpose of this research is to review the nexus of Internet of Things innovations to deliver Net Zero energy buildings (NZEBs) that can mitigate global warming for a sustainable biosphere. This will help achieve favourable energy efficiency for a sustainable world from the adverse climatic upheavals due to increased global warming. The specific objectives of the research are: i) To examine the gravity of emissions from non-energy efficient buildings and the extent to which they contribute to global warming; ii) To explore the components and capabilities of IoT technology and infrastructure that influence the design of internet of things; iii) To specify ways of integrating machine learning (ML) and artificial intelligence (AI) technology to reconstruct past climate events and improve future predictions. Data analysis was done at the National Construction Authority with a target population consisting of 350 technical and management staff. The research fronts a future of worldwide energy efficiency for a sustainable biosphere to be realized by mass implementation of the Internet of Things, M2M energy-efficient buildings technology.

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INTRODUCTION

The building sector has a key role to play in ensuring the biosphere's sustainability as the sector contributes enormous greenhouse gas emissions into the atmosphere, thus endangering the lives of all living things. To achieve meaningful energy efficiency, built environment technology should be considered so that smart energy buildings can be realized. Many factors contribute to global warming that negatively impact the climate and thus, world unsustainability.

"Zero-energy buildings are those that generate enough renewable energy to cover their yearly energy consumption needs", as defined by the United States Department of Energy (US DoE) (2015). According to the European Union Article 2, a practically zero-energy building with excellent performance shall be powered primarily by renewable energy sources, including those generated on-site or locally, European Commission (2020).

Net Zero Energy Building (NZEB), which generates as much energy as it uses over a year, has lately become a reality. Currently, only a limited percentage of very energy-efficient structures fulfil the requirements to be dubbed "Net Zero." Buildings that are Net Zero Energy are becoming more and more possible because of advancements in construction technology, renewable energy systems, and academic study. Some definitions of the term "net zero energy" differ, but most agree that these buildings combine exceptional architectural design with renewable energy technology to decrease their energy use, Steven Winter Associates Inc. (2016).

"Net-zero energy consumption Homes are capable of producing as much energy as they use and are constructed to maximize their energy efficiency via the use of airtight roofs, walls, windows, and foundations." N. Higgins-Dunn (2019).

The unpleasant effects of global climate change are a major issue for humanity in the twenty-first century. There are several natural catastrophes that are caused by seasonal shifts in the climate. These include extreme hunger, famine-related disease outbreaks (including Ebola), and population relocation. Furthermore, the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) says that the climate is changing and will continue to change considerably in the future. Developing and Least Developed Nations—exactly those countries with the least capacity to adapt—are likely to bear the brunt of these developments, which will be for the worse (Wright, 2008). Climate change is a certainty we have to live with. We have to accept that climate change is a fact of life. Climate-related disasters like floods and drought are occurring less often these days. As soon as one climate-related catastrophe is over, we are plunged into another! Floods, drought, tropical storms, and typhoons are just a few of the many ways that climate change might show up." Climate has a direct impact on our lives, and so must be handled seriously (GeSI, 2008).

METHODOLOGY

The approaches used by the researcher in gathering data are referred to as research methods. A questionnaire and a document review were used to collect data in this quantitative research. According to Green and Tull, a study design describes how the data will be gathered. The research strategy devised by the researcher utilizing the method of their choosing. Step-by-

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step instructions for conducting a research project are laid out here. An appropriate conceptual framework for a global Internet of Things-based smart energy building was constructed based on the critical ratio (C.R) validation of the study data using structural equation modelling (SEM) and expert opinion as part of the research to verify the suggested model for adoption and use of internet of things-based smart energy buildings. As to (Kothari, 2004) analysis includes a comparison of the outcomes of the various treatments upon the several groups and the making of a decision as to the achievement of the goals of research. It is critical to have a well-thought-out research design since it creates the foundation for the actual investigation. In order to identify the determinants, components, and capabilities that make up the Internet of Things (IoT) – application enablement platforms, this study used a combination of AMOS (Analysis of Moments Structures) to develop and validate an acceptable model using SEM (Structural Equation Modeling) and expert opinion.

The study data is used to develop conclusions about the whole population of interest. In sample surveys, a part of the population is selected and observations are made or data are collected on that part, and inferences are then extrapolated; to the whole population. Since in sample surveys, there are smaller workloads for interviewers and a longer time period assigned to data collection, most subject matter can be covered in greater detail than in censuses, (Nations, 2008). A total of 338 and 12 National Construction Authority (NCA) technical staff and management staff respectively, as of December 31st, 2015, were included in the target population. A major player in Kenya's built environment, the NCA works to improve the building rules that are allowed for use in the built environment, resulting in enhanced efficiency and effectiveness in service delivery. A breakdown of the demographics of the intended audience is shown in Table 1.

Table 1: Target Population

Population Particulars	NATIONAL CONSTRUCTION AUTHORITY (NCA)
Architects	41
Quantity Surveyors	44
Site Engineers	46
Land Surveyors	35
Electrical Engineers	39
Mechanical Engineers	41
ICT Engineers	49
Civil Engineers	43
Management Staff	12
TOTAL	**350**

(National Construction Authority, 2024)

The registered contractors were selected using a stratified and simple random sampling technique, with n>50+8m (where m is the number of independent variables) required for testing multiple correlations and n>104+m for evaluating individual predictors, as recommended by Green (1991). These sample size recommendations are based on detecting a moderate effect size (β>=.20), with a critical α <= .05, and an 80% power. As a result, NCA randomly chose 228 respondents from a total of 350 technical staff and Managers, dividing them into eight strata depending on the location of the contractor's work projects during the previous five years. Nairobi, Central, Eastern, Coast, Western, North Eastern, Rift Valley, and Nyanza were among the layers. As demonstrated in Table 2, the study's sample size was, therefore, two hundred and twenty-eight (228).

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Table 2: Sample Size

Staff Specialization	NATIONAL CONSTRUCTION AUTHORITY (NCA)	
	Sample Size	**Percentage Mean**
Architects	30	73.17
Quantity Surveyors	26	59.09
Site Engineers	31	75.61
Land Surveyors	22	62.86
Electrical Engineers	25	61.10
Mechanical Engineers	29	70.73
ICT Engineers	32	65.31
Civil Engineers	25	51.14
Management Staff	8	66.67
TOTAL	**228**	**65.07**

(Author, 2024)

RESULTS AND DISCUSSION

To examine the Gravity of Emissions from Non-Energy Efficient Buildings and the Extent to Which they contribute to Global Warming

This section presents the descriptive research findings on various factors considered concerning the study's independent variables which included the following Carbon Dioxide (CO2) problems, sustainable development, building sector already reducing carbon emissions, the extent non-energy efficient building emissions contribute to global warming and widely accepted climate impact predictions that illustrate the magnitude of the problem. Please assess the correctness of the following claims with how awareness and understanding of the Internet of Things smart building technology might impact smart building technology adoption using a 5-point Likert scale, where **Rating Scale:**(*1- Strongly Disagree; 2- Disagree; 3 – Fairly Agree; 4 – Agree; 5 – Strongly Agree*)

Table 3: Gravity of Emissions from Non-Energy Efficient Buildings and The Extent to Which They Contribute to Global Warming

Carbon Dioxide (CO2) Problems	5	4	3	2	1	Mean	SD
Due to continued human activities, unlike other heat-trapping gases, carbon dioxide tarries longer in the biosphere.	37 (21.5)	91 (52.9)	28 (16.3)	13 (7.6)	3 (1.7)	3.85	0.91
Instead of escaping into space, most of the outgoing shorter and longer wavelength radiation is kept within the atmosphere.	42 (24.4)	83 (48.3)	34 (19.8)	11 (6.4)	2 (1.2)	3.88	0.89
The more envelope of carbon dioxide on earth, the more negative impacts the biosphere will experience.	39 (22.7)	90 (52.3)	30 (17.4)	8 (4.7)	5 (2.9)	3.87	0.92

(Data Analysis, 2023)

From the findings on the gravity of emissions from non-energy efficient buildings and the extent to which they contribute to global warming, the study found that respondents agreed that due to continued human activities, unlike other heat-trapping gases, carbon dioxide tarries longer in the biosphere as shown by mean of 3.85, respondents agreed that instead of escaping into space, most of the outgoing shorter and longer wavelength radiation is kept within the atmosphere as shown by mean of 3.88 and respondents also agreed that the more envelope of carbon dioxide on earth, the more negative impacts the biosphere will experience as shown by mean of 3.87.

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Table 4: Sustainable Development

Sustainable Development	5	4	3	2	1	Mean	SD
By decarbonizing enterprise buildings emissions and other operations this can continuously improve energy efficiency by reducing their carbon footprints	46 (26.7)	50 (29.1)	46 (26.7)	22 (12.8)	8 (4.7)	3.60	1.15

(Author, 2023)

From Table 4, respondents agreed that decarbonizing enterprise buildings emissions and other operations can continuously improve energy efficiency by reducing their carbon footprints as shown by a mean of 3.60.

Table 5: Normality Results

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	Df	Sig.	Statistic	df	Sig.
IoT Technology	.123	172	.000	.950	172	.000
IoT Infrastructure	.106	172	.000	.959	172	.000
IoT Platforms	.102	172	.000	.963	172	.000
Access Technologies	.141	172	.000	.959	172	.000
Data Storage and Processing	.099	172	.000	.970	172	.001
IoT Data Analytics	.150	172	.000	.944	172	.000
IoT Security	.095	172	.001	.954	172	.000
IoT Components	.104	172	.000	.972	172	.001
IoT Capabilities	.154	172	.000	.921	172	.000
Open Systems IoT Reference Model	.108	172	.000	.956	172	.000

a. Lilliefors Significance Correction

Multivariate Normality	Kurtosis	C.R.
	137.953	16.839

(Author, 2023)

Endogenous variables were subjected to the Kolmogorov-Smirnov test to see if they were normally distributed. The degree of normalcy of the data is determined by this test, which looks for skewness, kurtosis, or both. When the Kolmogorov-Smirnov statistic p-values are greater than or equal to 0.05, according to Razali and Wah, the data is considered normal. Endogenous indicators and latent variable Internet of Things Based Smart Energy Building had p-values of .000, confirming departure from normalcy ($p< 0.05$), according to the findings of the study. For the multivariate Kurtosis, a test for multivariate normality found that its Critical Ratio (C.R.) is 137.953. In other words, when the C.R. exceeds 1.96, there is a considerable departure from normalcy.

To Explore the Components and Capabilities of IoT Technology and Infrastructure that Influence the Design of the Internet of Things

IoT Components

A consensus exists: the market is as crowded and confused as ever. More firms are fighting for a piece of the pie, and consumers have a hard time navigating it outside of ecosystems of cooperation and partnerships dominated by established businesses, I-SCOOP (2017).

Choosing the correct IoT platform for a firm that doesn't want to start from scratch but wants to integrate with an existing one is a challenge. What components should we be looking for in an IoT platform as we look through all of the options out there? It has been concluded, based on the findings of IoT Analytics (2016), that

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contemporary IoT platform architectures should have the following components or modules in order to develop anything from smart homes to large-scale industrial IoT, Berat, N. (2017).

Figure 1: The Components of an Internet of Things Application Enablement Platform; IoT Analytics (Scully, P. (2016))

<table>
<tr><td rowspan="6">Database
(Repository that stores important data sets)</td><td colspan="2">External Interfaces
(API's, SDK'S and gateways that act as Interfaces for third-party systems e.g., CRM and ERP)</td></tr>
<tr><td>Analytics
(Algorithms for advanced calculations and machine learning)</td><td>Additional Tools
Further development tools (e.g App prototyping, access management, reporting)</td></tr>
<tr><td colspan="2">Data Visualization
Graphical depiction of (real-time) sensor data</td></tr>
<tr><td colspan="2">Processing and Action Management
Rule engine that allows for (real-time) actions based on incoming sensor and device</td></tr>
<tr><td colspan="2">Device Management
Backend tool for the management of device status, remote software deployment and updates</td></tr>
<tr><td colspan="2">Connectivity and Normalization
Agents and libraries that ensure object connectivity and harmonized data formats</td></tr>
</table>

The eight IoT application enablement platform components which are architectural building blocks of IoT Analytics are:

Connectivity and normalization: Ensures proper data streaming and interaction with all devices by bringing multiple protocols and data formats into one "software" interface. Devices and sensors link to the IoT platform in many ways. If you're sending a lot of data, you'll want to choose a communication protocol that can handle that amount of data and the frequency with which it has to be transmitted. All devices must be able to communicate with one another to maintain consistent connection and standardized data formats, hence this communication module comprises agents and libraries that bring various protocols and data formats into a unified interface, Berat, N. (2017).

Device management: Ensures that connected "things" operate correctly by automatically patching and updating software and programs running on the device or edge gateways. To ensure that connected devices are updated and functioning effectively, an IoT platform's device management solution must be robust. Device management includes device provisioning, remote setup, and the manufacturer's ability to provide software or firmware upgrades over-the-air (OTA), as well as an out-of-the-box experience and troubleshooting, Berat, N. (2017).

Database: Scalable storage of device data significantly increases the data volume, diversity, velocity, and veracity requirements for hybrid cloud-based databases. This module is a critical component of an Internet of Things platform. Cloud-based data storage enables scalability in terms of data volume, diversity, velocity, and veracity. Choosing the right database technology is vital to the success of the majority of initiatives. Processing and administration of actions: bring data to life via rule-based event-action triggers that enable the execution of "smart" actions depending on sensor data. This section of the IoT platform brings to life the data that was recorded in the connection and normalisation module and then saved in the data storage. This module is comprised of an integrated logic unit dubbed the Rule engine - a rule-based event-action trigger that enables "smart," real-time actions based on sensor and device data. It automates processes depending on events and times. Here, customized procedures and functionalities are readily deployed. Frequently, the technical implementation of a rule engine takes the form of

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an IF-This-Then-That rule (IFTTT), Berat, N. (2017).

Analytics: Executes a variety of complicated analyses, ranging from simple data clustering and deep machine learning to predictive analytics, to extract the most value from the IoT data stream. Oftentimes, sophisticated data analysis requires the use of artificial intelligence and machine learning. The analysis, processing, and transmission of certain types of data can be critical and/or occur in environments that require analytics and intelligence at the so-called edge (where devices/assets and specific gateways are located): this is partially what edge computing and fog computing are about and where edge platforms come into play. SCOOP-I (2017). Data visualization helps people to identify patterns and trends using visualization dashboards that display data graphically through line, stacked, or pie charts, as well as 2D or 3D models. Y. Kolesnyk (2019). This enables the user to interact with the system's processed data. Additionally, these technologies enable IoT developers to prototype, test, and market IoT use cases by developing platform ecosystem applications for displaying, managing, and controlling linked devices. They provide additional development tools (for example, app prototyping, access control, and reporting). (N. Berat 2017; Y. Kolesnyk 2019).

External interfaces: Using built-in application programming interfaces (API), software development kits (SDK), and gateways, interact with third-party systems and the rest of the larger IT ecosystem. Y. Kolesnyk (2019). The IoT platform should be built in such a way that it facilitates the development of all bespoke web and mobile apps for cloud data management. Developers might utilize a more conventional server-side SDK by invoking API calls from web or mobile applications. It is critical to discover, develop, implement, and test any APIs required by external organizations. Additionally, the external interfaces component comprises gateways that serve as interfaces to third-party systems (e.g., ERP, CRM). When assessing IoT data platform alternatives, keep it simple. (Berat, N., (2017). Year after year, the price of individual connectable sensors has decreased considerably, to the point that they now cost a fraction of what they did five years ago. Indeed, they are getting increasingly inexpensive, to the point that instrumenting everything has become the new standard, Mathieu, A. (2015).

IoT Capabilities

As a technology-centric offering, an Application Enablement Platform (AEP) serves as the middleware core for a collection of connected or independent IoT solutions that may be developed by the client's developers. IoT devices and the Internet of Things may be connected via an Application Enablement Platform, allowing industrial businesses to use predictive maintenance and machine learning as well as a host of other applications. According to industry forecasts, the global market for IoT platforms is estimated to reach $63.4 billion by 2026, making IoT application enablement one of the most popular IoT platforms, Hilton, S. (2018).

Finally, IoT is an integrated strategy to utilize data from devices, assets, and environmental/contextual features in combination with other data in a meaningful and useful way, thus further technologies are added to the scope of IoT deployments depending on use cases and sectors. Since IoT platform manufacturers have to consider all of these factors when determining their offerings, it's no surprise that this guide to IoT platform selection is also a guide for those looking to acquire an IoT platform, I-SCOOP (2016).

Application Enablement Platform Capabilities include the following: *Device Connection, Application, and Data Management*: M2M and IoT solutions bring together difficult device connection, application, and data management procedures. M2M and IoT will grow as new demands and capabilities emerge in each area, allowing for a dynamic value chain and a rising ecosystem of service providers, Machina Research (2014). To manage the scale and heterogeneity (of devices and protocols) on a

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smaller number of platforms, agnosticism and abstraction are used together. This enables developers to focus on application development rather than specific communications technologies or device features, Machina Research (2014). There must be a focus on data in the next generation of AEP systems so that applications may easily access and mine that data for important business insights. Data gathered may be securely shared with applications, Global Information (2017). An application enablement platform provides common horizontal solution components that may be reused across industries and market segments to expedite and simplify the construction of IoT solutions, Vandaele, P. (2015).

Scripting Engine: Scripting is an excellent tool for developing event-driven applications. In event-driven applications, each device listens for and reacts to different other occurrences. In JavaScript, event loops enable you to execute several actions concurrently without waiting for other processes to finish. This enables real-time event response, parallel processing of various tasks, and the simultaneous response of several devices to the same event. This significantly helps to the conservation of valuable battery power. Badami, V. (2016). With the increased use of JavaScript in various applications, there are numerous JavaScript development resources available, including JavaScript libraries such as Underscore.js, lodash, traverse, and Async; testing tools such as Blue Ridge, SugarTest, FireUnit, and JSLint; and client-side and server-side JavaScript APIs. JavaScript developers working with the Internet of Things have access to advanced frameworks and engines such as CycloneJS, IoT.js, JerryScript, and Duktape that are optimized for restricted devices. Badami, V. (2016).

Integration Framework: It enables agile IoT systems to be rapidly deployed to solve evolving business needs. The framework is an IoT solution enablement ranging from industry-specific applications to advanced data marketplaces. Multiple ecosystem partners are providing IoT platforms, data services and enterprise data systems; Extensible architecture that enables interoperability with legacy platforms and migration to next-generation systems; Vendor agnostic approach to create optimal purpose-built IoT solutions and IoT solution enablement ranging from industry-specific applications to advanced data marketplaces, InterDigital Inc (2016).

Software Development Kits: There are Open-Source SDKs available for "developing secure IoT gateway data and control orchestration applications." It enables applications to gather data from devices, deliver it to the data centre, and execute control signals generated by the Data Center Components (DCC). It includes device libraries with source code that enable developers to create applications that connect to and are controlled by certain IoT Hub services. The IoT Gateway SDK enables developers to create and deploy gateway intelligence that is tailored to their specific needs. It provides source code that simplifies the process of developing a gateway application by automating dynamic module loading, configuration, and data pipelining. The IoT Device SDK is a collection of open-source libraries for developing IoT products and solutions across a variety of hardware platforms, Irandoust, K. (2016).

Web Services: Shortly, the Internet of Things (IoT) idea sees common objects such as household appliances, actuators, and embedded systems of various sorts being connected to the Internet. These components will unite to form a distributed network with sensing capabilities, opening up previously unimagined economic opportunities and spurring the development of new services such as energy monitoring and management for homes, buildings, and industrial processes, Castellani, A. P., et al. (2011). Web services are highly accessible components of distributed applications. They allow us to mix applications developed in diverse languages on dissimilar platforms. Web services are the building blocks upon which distributed applications are built. They are often used to construct applications that

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communicate with the World Wide Web through a web browser or are otherwise connected to the World Wide Web. The technology that supports web services, on the other hand, has nothing to do with the World Wide Web or its associated technologies, such as web browsers. Vasseur, J-P., & Dunkels, A. (2013); A. P. Castellani et al. (2011).

Due to Web-related technologies' widespread use, web services have experienced a dramatic rise in general-purpose IT acceptance in recent years. Libraries for building web service-oriented applications are available for all major programming languages. As a result, Vasseur, J-P., & Dunkels, A. (2010) report that web services are used in the development of many current IT systems.

In the past, web services were connected with large-scale servers, databases, and systems. Use this technology to connect database systems in a framework that permits the expression of high-level concepts and dependencies, while yet being short enough to be standard across a wide range of applications. Existing web service-oriented systems, programming libraries, and knowledge may easily be transferred to the new domain of smart object applications by using web service technology, Vasseur, J-P., & Dunkels, A. (2013).

Using AEP2.0 solutions allows M2M solution providers to make the most of their most valuable asset: data. For businesses, AEP2.0 enables them to quickly and cost-effectively get access to high-value business data, which they can then use to create new business models. Building technology of the future must be data-driven, allowing businesses to construct M2M apps that take advantage of the linked world of gadgets. Data-centric and analytics-driven features are included in AEP2.0, which inherits the first-generation enablement platform's foundational features including connection, vertical integration, and limited analytical capacity. An abstraction layer between connected devices and apps is required for AEP2.0 solutions to simplify data collection and storage for application developers, mine the data for crucial business insights and securely publish the data to applications and third parties. AEP2.0 systems must be able to handle massive amounts of data and perform batch and real-time analyses to be effective, Banerjee, A. (2013).

For today's M2M solutions, cloud-based Smart Building Technologies can provide endless data capacity growth and unrivalled scalability because of their sophisticated load balancing and auto-scaling features. As a result of today's Smart Building Technology, M2M systems can grow to serve millions of devices and millions of subscribing apps. If a network or hardware failure or other unforeseen event occurs, they may also provide sophisticated failover capabilities, such as redundancy in processing nodes and data storage across various locations. The Banerjee, A. (2013). M2M connections are expected to expand from two billion in 2012 to 12 billion in 2020, according to Machina Research (2010).

Connectable sensors are becoming more commonplace, which opens up new possibilities and raises the prospect of a brighter future for the construction sector. However, two additional difficulties are emerging: An IoT Tower of Babel has been built: What are the best practices for integrating sensors that utilize diverse protocols and data formats? To put it another way, how and where should they be connected to obtain the maximum benefit? We need a platform that makes it simple to get insights from the data we collect. When everything changes so rapidly, we need a platform that can keep up with it. Mathieu, A. says that fresh ideas, new connections, and new applications are always emerging. Mathieu, A. (2015) developed the IOT Application Enablement Platforms in collaboration with several organizations to produce a solution that tackles both issues.

To explore the components and capabilities of IoT technology and infrastructure that influence the design of the Internet of Things, the following aspects were considered. Respondents were expected to state the level of their agreement using 5 level Likert scale where the **Rating Scale:**(*1- Strongly Disagree; 2- Disagree; 3 – Fairly Agree; 4 – Agree; 5 – Strongly Agree*)

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Table 4: IoT Technology

IoT Technology	5	4	3	2	1	Mean	SD
All several technological layers of IoT play a role in the route from simply connecting 'things' and IoT devices to building applications that serve a clear goal.	32 (18.6)	80 (46.5)	29 (16.9)	19 (11)	12 (7)	3.59	1.12
IoT is entering and shaping the daily operation of many industries, offices and homes.	16 (9.3)	70 (40.7)	45 (26.2)	28 (16.3)	13 (7.6)	3.28	1.08
A related and cost-effective user-level IoT application is the support of IoT-enabled smart buildings.	30 (17.4)	79 (45.9)	40 (23.3)	22 (12.8)	1 (0.6)	3.67	0.93
Devices act as an interface between the real and the digital worlds.	44 (25.6)	80 (46.5)	30 (17.4)	12 (7)	6 (3.5)	3.84	1.00
IoT technology stack has various layers, starting with IoT devices, and myriad technologies per layer.	79 (45.9)	45 (26.2)	27 (15.7)	11 (6.4)	10 (5.8)	4.00	1.18
IoT gateways enable to actually do something with all the data coming from 'IoT-enabled' things or connected objects.	40 (23.3)	53 (30.8)	51 (29.7)	20 (11.6)	8 (4.7)	3.56	1.11

(Data Analysis, 2023)

In Table 2, the outcome revealed that respondents agreed all several technological layers of IoT play a role in the route from simply connecting 'things' and IoT devices to building applications that serve a clear goal as shown by a mean of 3.59, respondents agreed IoT is entering and shaping the daily operation of many industries, offices and homes as shown by mean of 3.28 and respondents agreed a related and cost-effective user-level IoT application is the support of IoT-enabled smart buildings as shown by mean of 3.67 as well as IoT gateways enable to do something with all the data coming from 'IoT-enabled' things or connected objects as shown by 3.56. Moreover, the respondents agreed that devices act as an interface between the real and the digital worlds as shown by 3.84 and the IoT technology stack has various layers, starting with IoT devices, and myriad technologies per layer as shown by a mean of 4.00.

To Specify Ways of Integrating Machine Learning (ML) and Artificial Intelligence (AI) Technology to Reconstruct Past Climate Events and Improve Future Predictions

Machine learning (ML) and artificial intelligence (AI) increasingly influence lives, enabled by significant rises in processor availability, speed, connectivity, and cheap data storage. AI is advancing medical and health provision, transport delivery, interaction with the internet, food supply systems and supporting security in changing geopolitical structures. Society is approaching the era of self-driving cars, helping medical practitioners avoid misdiagnoses, accurate speech recognition, and receiving tailored purchase suggestions. Most applications are beneficial, although ethical issues exist, e.g. Bostrom (2014), New Scientist (2017). Simultaneously, evolving lifestyles must interact safely with climate change. There is a growing realization that climate change impacts are not an isolated threat, instead needing more holistic responses alongside addressing other societal issues. Climate change is a complex scientific and multifaceted issue, amenable to ML and AI analysis, but in general, this has not yet occurred. Many ML algorithms have been available for decades, and possibly most notably neural networks. However, until recently, constraints of computational architecture and power have restricted their application, especially for issues as data-intensive as climate change.

Various names describe new computational methods, including big data, ML and AI. Big data

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is concerned with using complex datasets, so large that traditional analysis techniques are unsuitable. AI is a form of computer science, where the goal is often to teach a computer to complete tasks a human cannot do, and generally involves decision-making in different contexts. ML is a sub-area of AI where computers learn relationships from large training datasets. For climate and weather applications, a simplistic characterization can be: (i) big data as the collection for analysis of meteorological—or Earth System-related measurements, and high spatial and temporal resolution Earth System model (ESM) outputs, (ii) ML as refining or discovering new linkages between locations, times and quantities in the datasets (e.g. where sea surface temperature features aid weather prediction months later over land regions) and (iii) AI as building on connections that ML discovers, to provide automated warnings and advice to society of approaching weather extremes. The recent ease of application of ML methods through better computational capability is partly supported by the novel use of computer graphical processing units (GPUs), noting that GPU speed is increasing faster than standard central processing units (Baji, 2018). Others (e.g. Burr, 2019) suggest more inventive use of computer memory, to make calculations both more efficient and much nearer where the data is stored.

There is still a long way to go before AI becomes a reality in smart building management, although it is widely regarded as the future. For years, the concept of "smart buildings," which include energy management systems and other preventative maintenance features, has been discussed in depth in many publications. Now that artificial intelligence is on the increase, we should expect to see even more automation. Mckendrick, J. (2020). Artificial intelligence (AI) in buildings is opening up a plethora of new possibilities. Smart devices and the Internet of Things are used in a wide range of applications. Data analysis and insight extraction must be lightning fast if new applications are to be created to make use of this rapid-moving data. According to Green, there is both a conviction in AI and a willingness to invest in its solutions for smart construction. Because of how quickly these technologies are evolving, "AI is seen as the logical next step and should assist boost operational efficiency and effectiveness." Mckendrick, J. (2020).

System-Level Impacts

While the previous section describes ML applications that are directly beneficial or detrimental to climate change mitigation, many societal ML applications may not have clear immediate impacts on climate change. However, many of these applications can have broader societal implications beyond their immediate impact, and these system-level effects can influence GHG emissions both positively and negatively. Though these kinds of impacts may be hard to quantify, they have the potential to outweigh immediate application impacts and are extremely important to consider when evaluating ML use cases. One pathway to system-level impacts occurs when ML enables changes to a technology that in turn affects how that technology is used. For example, rebound effects can occur when ML increases the efficiency of a service. While improved efficiency may result in lower GHG emissions per use, a decrease in cost may lead to increased consumption of the same or another good. This can eat into GHG benefits from efficiency gains or even counteract them, Inˆes M.L. Azevedo (2014). Such rebound effects can be direct, for example by allowing a manufacturing plant to use ML-enabled efficiency gains to increase production of the same goods, thereby (partially) negating emissions savings.

Even larger impacts can be expected from more structural types of rebound effects, Dauvergne, P. (2020). Which occurs for example with ML-enabled autonomous driving. Specifically, autonomous vehicles can improve fuel efficiency, but they may also lead to higher rates of individualized vehicle travel, potentially increasing overall energy use and emissions if autonomous vehicles are not shared and/or electrified, James M. Anderson, et al. (2016); Felix, C. et al. (2019); Zia W. et al. (2016).

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RECOMMENDATIONS

The gravity of emissions from non-energy-efficient buildings should be slowed by engaging in energy-efficient buildings in order to slow down the extent to which they contribute to global warming. The researchers found that the lack of proper building codes and lack of enforcement for existing building codes has greatly hampered the growth of technology adoption in smart buildings. The study recommends that KEBS and NCA harness the adoption of Eurocodes to make sure that all buildings designed have an element of energy-saving mechanisms in place, for the biosphere's sustainability.

Secondly, the incorporated components and capabilities of IoT-based smart energy buildings are at the core of the IoT technological revolution. The study recommends the built industry adopt IoT technologies that incorporate components and capabilities among others and roll out the technologies en-masse in order to counter the world's global warming that threatens the biosphere. The researchers recommend more intelligent building designs and the IoT – Driven Energy Efficient Smart Energy Building technology so that more devices can be physically interconnected and realize the convergence of building science, big data real-time analytics and IT telecommunications virtually so that the devices can reach critical mass and have a significant impact on reducing our reliance on the power grid and coal, which contributes a lot to global warming that negatively impacts on the biosphere. This is all about the M2M devices achieving critical mass. As the number of devices increases, so will the energy use, necessitating energy optimization. When more of us decide to make the leap toward greener practices, smart buildings will easily achieve energy efficiency without any reasonable doubt. This can easily be achieved, thanks to the wide range of enabling technologies. This will help stem run-away global warming making a favourbable planet's biosphere for habitants to live in.

CONCLUSION

True wealth comes from innovation. The confluence of Big Data, Connectivity, and Artificial Intelligence. To counter the world's climate change that is en route to wipe out life, technological solutions to climate change should be considered.

REFERENCES

Badami, V. (2016). Why JavaScript is used in IoT.

Baji, T. (2018, March). Evolution of the GPU Device widely used in AI and Massive Parallel Processing. In *2018 IEEE 2nd Electron Devices Technology and Manufacturing Conference (EDTM)* (pp. 7-9). IEEE.

Banerjee, A. (2013). The Future of M2M Application Enablement Platforms, Heavy Reading. Pg. 91 https://cdn2.hubspot.net/hub/246745/file- 326224805- pdf/Heavy_Reading_- TheFutureofM2MApplicationEnablementPlatforms_September_2013.pdf?t=1406838830743

Berat, N. (2017). What are the expectations from an IoT platform? https://www.quora.com/What-are-the-expectations-from-an-IoT-platform

Bostrom, N. (2014). Superintelligence*: Paths, Dangers, Strategies. (Oxford: Oxford University Press).* Google Scholar

Burr, G. W. (2019). A role for analogue memory in AI hardware. *Nature Machine Intelligence*, *1*(1), 10-11.

Castellani, A. P., Gheda, M., Bui, N., Rossi, M., & Zorzi, M. (2011, June). Web Services for the Internet of Things through CoAP and EXI. In *2011 IEEE International Conference on Communications Workshops (ICC)* (pp. 1-6). IEEE.

Dauvergne, P. (2020). Peter Dauvergne. Is artificial intelligence greening global supply chains? Exposing the political economy of environmental costs. Review of International

 This work is licensed under a Creative Commons Attribution 4.0 International License.

Political Economy, (0):1–23. doi: 10.1080/09692290. 2020.1814381.

European Commission, (2020). Energy. https://ec.europa.eu/energy/content/nzeb-24_en

Creutzig, F., Franzen, M., Moeckel, R., Heinrichs, D., Nagel, K., Nieland, S., & Weisz, H. (2019). Leveraging digitalization for sustainability in urban transport. *Global Sustainability*, *2*, e14.

GeSI, 2008. p. 8, Journal of Leadership, Accountability and Ethics, 13(3), 2016, http://www.ryerson.ca/content/dam/tedrogersschool/research/ResearchMattersNewsletter/Issue32/E- waste_Management_Canada_Published.pdf

Global Information, 2017. Operational Infrastructure for Value-Based M2M BusinessModels- Market Research Report, https://www.giiresearch.com/report/heav320800-operational-infrastructure-value-based-m2m.html

Higgins-Dunn, 2019. Higgins-Dunn, N. (2019). Net-zero energy homes have arrived — and are shaking up the US housing market. Published Thu, Feb 14 2019 8:59 AM ESTUpdated Thu, Feb 14 2019 4:09 PM EST. https://www.cnbc.com/2019/02/14/homes-that-produce-their-own-energy-might-be-the-future-and-california-is-inching-closer.html

Hilton, S. (2018). The top 4 industrial enterprise requirements of IoT application enablement platforms (AEP)

I-SCOOP, (2016). IoT platforms – IoT platform definitions, capabilities, selection advice and market.

I-Scoop, (2017). Facility management and smart buildings: smart data, insights and integration.

Inˆes M.L. Azevedo, (2014). Inˆes M.L. Azevedo. Consumer end-use energy efficiency and rebound effects. Annual Review of Environment and Resources, 39(1):393–418, 2014. doi: 10.1146/annurev-environ-021913-153558

InterDigital Inc, (2016). InterDigital IoT Solutions. IoT integration framework. https://www.industrialautomationindia.in/productsitm/5933/wot.io%E2%84%A2/products

Irandoust, 2016. Irandoust, K. (2016). IT Next. Best SDK's for the Internet of Things

James M. Anderson, et. al. (2016). James M. Anderson, Nidhi Kalra, Karlyn D. Stanley, Paul Sorensen, Constantine Samaras, and Tobi A. Oluwatola. Autonomous Vehicle Technology: A Guide for Policymakers. RAND Corporation, Santa Monica, CA, 2016. doi: 10.7249/RR443-2

Kolesnyk, 2019. Kolesnyk, Y. (2019). What is an IoT platform? What is an IoT platform architecture? Published on August 22, 2019.

Mckendrick, J. (2020). Smart Buildings with AI: It's Only the Beginning.

Machina Research, (2010). The critical role of connectivity platforms in M2M and IoT application enablement www.machinaresearch.com.

Machina Research, (2014). The critical role of connectivity platforms in M2M and IoT application enablement. https://machinaresearch.com/static/media/uploads/machina_research_white_paper_- _connectivity_platforms_and_m2m_iot_app_enablement.pdf

Mathieu, A. (2015). SOGETI SMART BUILDING, https://www.ibm.com/blogs/bluemix/2015/05/sogeti-high-tech-and-ibm/

New Scientist. (2017). *Machines that Think: Everything you need to know about the coming age of artificial intelligence*. Hachette UK.

Chase, N., Maples, J., & Schipper, M. (2018, June). Autonomous vehicles: Uncertainties and energy implications. In *2018 EIA Energy Conference* (Vol. 5, p. 2018).

Article DOI: https://doi.org/10.37284/eajit.7.1.2524

Scully, P. (2016). 5 Things To Know About The IoT Platform Ecosystem. https://iot-analytics.com/5-things-know-about-iot-platform/

Steven Winter Associates Inc., (2016). Net Zero Energy Buildings.

Vandaele, P. (2015). Integration is key for successful enterprice internet-of-things Applications. https://www.waylay.io/blog/integration-is-key-for-successful-enterprise-internet-of-things-applications

Vasseur, J-P., & Dunkels, A. (2013). Building an IoT web services framework with smart objects.

Wadud, Z., MacKenzie, D., & Leiby, P. (2016). Help or hindrance? The travel, energy and carbon impacts of highly automated vehicles. *Transportation Research Part A: Policy and Practice*, *86*, 1-18.

Wright, 2008. Observing the Climate—Challenges for the 21st Century.

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