

Future of Commissioning

Monier Madison Ouabira*

ABSTRACT

Technological developments, growing need for energy efficiency, and smart system integration are helping to define commissioning going forward. Emerging developments in the commissioning process—digitalization, automation, budget integration, software use, whole building commissioning (WBCx), continuous commissioning (OCx), and thorough commissioning—are investigated in this work. The study emphasizes how Grid-Interactive Efficient Buildings (GEB) and Automated Systems Optimization (ASO) might help to increase sustainability, performance, and efficiency. Also under discussion as a reasonably affordable method of energy management is Energy as a Service (EaaS). The study also discusses the need of Environmental, Social, and Governance (ESG) reporting and the application of Independent Data Layers (IDL) for better data management and monitoring. Future commissioning techniques also take health and connection trends under great importance. The results imply that in the commissioning process, a more integrated, technologically advanced approach will improve resilience, dependability, and efficiency.

Keywords: Commissioning, Green Buildings, Re/Retro-Commissioning, Sustainability.

Submitted: November 26, 2024

Published: April 09, 2025

 10.24018/lejarch.2025.4.2.48

Old Dominion University, USA.

*Corresponding Author:
e-mail: monier.ouabira@gmail.com

1. INTRODUCTION

The future of commissioning is bright; this is owing to the rapid advancement in technology that is changing how the construction process is aligned. A steep focus on green energy initiatives and smart city design requirements have further refined construction sector, and more changes are anticipated in the future (Singh & Anumba, 2023). Technology such as machine learning, robotics, and motion sensor technology is being used to automate and digitize building construction, helping to save on time, resources, and budgets. The construction sector is expected to push towards greener energy and smart building designs to help users achieve more comfort, reliability, and efficiency in the use of buildings and structures. As such, advancement in technology means that buildings will adopt more and more sophisticated devices and gadgets, as well as functionality, offering users greater usability, comfort, and reliability.

2. DIGITIZATION OF THE COMMISSIONING PROCESS

The rapid advancement in technology over the past half century has influenced the construction sector in numerous ways. Digitization has enabled for automation and integration of various functionalities into one module, which has enabled for seamless success in delivery of highly functional systems and structures. It is worth noting that digitization has affected every phase of the commissioning process – from idea conception, design, construction, and maintenance. The benefits associated with digitization have enabled for wide adoption of emerging technology trends into the commissioning process (Singh & Anumba, 2023). Development of digital and automated tools and equipment, together with better testing tools has enabled for development of more superior and elegant systems and structures. Digitization has enabled for development of smart structures, which can detect environmental changes and act autonomously to address the environmental change. Smart devices in buildings and other engineering structures have become a norm in most commissioned structures.



Green energy innovations and inventions have also become a major digitization effort to ensure that commissioned structures have the most optimal energy use and conservation.

The digitization revolution has enabled for faster development of engineering structures, as well as easy transformation and upgrade of already existing structures. Digitization has enabled for faster implementation of construction services as well as higher standardization of functionalities and designs ([Westminster Forum Projects, 2017](#)). Digitization has enabled for better management of energy, resources, and equipment, reducing costs while enhancing functionality and efficiency. This has enabled for cheaper construction process and higher reliability of engineering structures. Digitization has enabled for easy and early detection of errors and discrepancies, which is achieved from constant testing and evaluation of engineering systems to determine their efficiency. Automation of maintenance and management functionalities has enabled for effective commissioning processes ([Westminster Forum Projects, 2017](#)). The need for automation has also enabled for the use of cloud-based web applications to ensure that data is updated in real time.

Many software solutions and equipment have been invented for the sole purpose of enhancing the effectiveness of the commissioning process. The emergence of machine learning, internet of things, big data and analytics, biometrics, and many other technological inventions and trends have pushed for higher effectiveness in the commissioning process ([Pacific Northwest National Laboratory, 2005](#)). Emergence of the Internet of Things (IoT) and digital economy has revolutionized how every sector operates. In the construction sector, the internet of things has played a big role in revolutionizing how information management is handled. The internet of things has enabled for easy automation of devices and connectivity between various systems and structures in buildings. Security management is one area that has highly benefited from the internet of things because CCTV installation depends on network efficiency ([Westminster Forum Projects, 2017](#)). Similarly important is the fact that biometric and sensor technology has benefited from the use of computer networks. The internet has also become an actively sought after utility in buildings and structures. As such, structural engineers have been tasked with designing highly usable structures that can support internet connectivity. It is evident that the commissioning process has already adopted technological trends and digitization, however, the process still requires further refining through adoption of newer technological trends and solutions. Every potential upcoming invention should definitely be evaluated and assessed and if its value exceeds costs and associated risks, it should be adopted into the commissioning process to guarantee high performance results. This is owing to the many challenges still facing commissioning, which need to be addressed through digitization and innovation ([Westminster Forum Projects, 2017](#)). It is anticipated that more digitization would be adopted into the commissioning process into the future. As such, the future of the commissioning process would be full of digitization.

3. AUTOMATED SYSTEMS OPTIMIZATION (ASO)

Automation is a current technological trend in all industries and sectors. Technological advancement has enabled massive operations at the touch of a button and thus has been actively adopted in the construction sector. Despite its uptake in the sector, it is anticipated that further automation moves would be invented to reduce the cost, resource use, and time used to make structures ([Pacific Northwest National Laboratory, 2005](#)). Automation is expected to reduce costs and enhance usability and efficiency. One automation trend that is expected to increase in use is the automated systems optimization (ASOs). ASOs entail the use of algorithms to optimize the operations of buildings and their maintenance. The algorithmic ASOs help to auto regulate many engineering systems of buildings such as lighting, heating, ventilation, air and conditioning (HVAC), and other automation systems. Automated systems are increasing in popularity because of the possibility of collecting data, which aids in monitoring and tracking of performance as well as associated costs ([Westminster Forum Projects, 2017](#)). It is worth noting that ASO systems have the capability of identifying trends and patterns, as well as improve reduce energy consumption of building performance.

[Pacific Northwest National Laboratory \(2005\)](#) confirms that ASO systems have high efficiency to deliver energy savings. It is worth noting that ASO can detect and address issues and problems in real time, thereby saving on maintenance costs. Automated adjustment of systems and structures has also resulted in reduced energy consumption, which has further reduced on costs. ASO systems are advantageous because they are easy to implement, and they can be implemented on both new as well as existing structures ([Singh & Anumba, 2023](#)). Another benefit of implementing ASO systems is reduced emissions, which is due to the automated detection of various components of emission gasses. It is also worth noting that ASO systems do not require many initial equipment or system changes, which makes it cost effective.

The main goal of automation is to improve performance results. In this case, the automation process aids in reducing the turnaround time, data collection and decision making in real time, as well as

reporting of performance results. Automation has helped to detect issues and discrepancies in real time, which has increased productivity and efficiency. Automation is also effective in improving accuracy and speed (Singh & Anumba, 2023). Automation is actively used in process-based systems to help in managing the slack time. This has enabled in achieving standardization, accuracy, and high speed. Automation is actively used in the construction sector to ensure that systems are switched on or off as scheduled. Automation has also enabled for better management of resources since some expert systems and intelligent machines are able to forecast and thus guide planning and budgeting.

When implementing ASO solutions, building owners are supposed to work with certified energy managers, building commissioning agents, and sustainability experts (Pacific Northwest National Laboratory, 2005). The combined expertise and experience of such a commissioning team would enable for effective implementation of ASO solutions to realize their full potential. An evaluation of the trend in the use of ASO in the commissioning process shows that the future of commissioning would entail detailed implementation of automation and ASO systems in every aspect of commissioning (Singh & Anumba, 2023).

4. INTEGRATING BUDGETS MORE EFFECTIVELY

Budgeting is one of the challenging areas in engineering project management. This is because of the scarcity of resources and funding, which challenges project success (Westminster Forum Projects, 2017). In light of this, comprehensive and integrated budgeting skills are required to ensure that wastes can be minimized and available funds can be used for delivery of a superior commissioned project. Integrated budgets depend on the use of the independent data layer and internet of things, which enables for timely real time documentation of signals. This helps to ensure that engineers can get updated signals that influence their decision-making. Integration of budgets entails centralizing all the fiscal reports and statements such as liquidity account, balance sheet, and profit and loss accounts.

It is worth noting that the integrated budgets require creation of the integration joint board, which helps in management of the budgets. Integrated budgets consider including budgeting for building materials, technological equipment and infrastructure, as well as other utilities necessary for delivery of a superior and reliable structure. Integrated budgeting approach enables for execution of all the steps of the budgeting process – budget preparation, budget legalization, budget execution, and budget accountability. Effective budget preparation is key in developing a good and appropriate budget that caters for all budgetary needs. Integrating the budgets ensures that the planning phase of commissioning is done appropriately, effectively estimating the costs of each element or process and ensuring that redundancy and wastes is eliminated. It is worth noting that integrating budgets helps to save on time and personnel required to work on budgeting tasks. Integration of budgets helps to save on time and guarantee better management of resources. According to Pacific Northwest National Laboratory (2005), integrating budgets helps to eliminate drudgery of compiling and validating data. Integrated budgets have more functionality that helps parties to remain updated on the current state of budget needs and plans. The integrated budget systems come with reporting infrastructure, which helps to keep stakeholders updated on trends and red flags that need to be addressed.

Integrated budgets have many benefits. The first major benefit is better decision making. Integration helps commissioning team to see which areas are over budgeted or under budgeted, which triggers changes in the budgeting process (Pacific Northwest National Laboratory, 2005). Another benefit of integrated budgets is better accuracy and efficiency in operations. Integrated budgets enable for real time data recording and tracking, which removes all discrepancies and redundancy of data. This enables for better collaboration among commissioning team members as well as building users. It is worth noting that integrated budgeting also enables for better forecasting. Forecasting is an important budgetary tool that enables organizations to plan according to seasonal expectations. This is critical in commissioning as it helps to offer reliable budget expectations, which guide resource allocation. Integrated budgeting is also beneficial because it enables for greater compliance with all monetary laws and regulations (Pacific Northwest National Laboratory, 2005). This has helped institutions to have higher reliability in complying with all state and trade laws. Another benefit of integrated budgets is higher visibility of transactions and accountability. Integrated budgets help to eliminate unnecessary redundancy and discrepancy in data, which enhances accountability. It is anticipated that integrated budgeting would continue into the future to guarantee that commissioning process would be effective in delivering high quality engineering buildings and structures.

5. SOFTWARE USE FOR COMMISSIONING SERVICES

Software use has become a common trend in the commissioning process due to the many benefits it offers to building construction. In commissioning, software is actively used as a framework for the

commissioning process as well as for management of various functionalities of the building (Fischer, 2021). In the commissioning process, the software is used for documentation and tracking of processes, replacing pen and paper in documentation. In this case, it is called Cx software, and two of the best examples include Commissioning & Completions Management Software (CCMS) and Commissioning Management Software (CMS). Apart from the Cx software, software is actively used in commissioning to help in operation and management of systems and equipment. Software guides commissioning engineers to automate and monitor processes and systems (Fischer, 2021). This helps to offer visibility to processes and milestones, enabling easier communication of such progress to team members. In today's technological world, the commissioning team can use both cloud based as well as stand-alone management software.

Software integration in construction systems is a key trend and it is expected to increase in the future, enabling for automation of functionality and services. Integration of software in the commissioning process has enabled for easy centralization of tasks and transactions. Centralization enables for fast service delivery to clients and delivery of superior systems and structures. Software is also used to complete pre-commissioning checklists and fill out test records when rectifying systems for higher efficiency (Fischer, 2021). The software also enables for the listing of O&M manuals and their status, as well as logging of pictures. Software use has enabled for easy data collection in real-time, which enables in addressing discrepancies and detecting challenges. Software use detects challenges and problems earlier on in the commissioning process, enabling for easier fixes as compared to later detection. Software use in commissioning has enabled for easy management of large-scale projects, since integration enables for centralized tracking and monitoring.

Software is beneficial in construction because it helps in management of various things such as temperature, humidity, power usage, and many other things (Fischer, 2021). Software use has enabled for easy automation and real-time tracking of tasks and activities. Software helps to easily track and record data, as well as data analytics that guides in decision-making. It is worth noting that software use has enabled for remote access to facilities and services in buildings and structures. One major aspect that has greatly benefited from use of software in buildings is security management, where software is used to manage building surveillance, enabling users to get notifications for all surveillance data captured (Fischer, 2021). Software use in commissioning has also enabled for better management and coordination of activities and tasks. Software use has enabled for real time tracking and detection of errors and challenges, which enables for timely address to issues. Based on the highlighted benefits it is anticipated that software use would continue in the commissioning process. Software use and digitization has become a leading trend and there is need for all commissioning engineers to be experienced in the use of software for automation, management, and tracking.

6. WHOLE BUILDING COMMISSIONING

Whole building commissioning (WBCx) is another trending approach to commissioning that has taken the industry by storm (Fischer, 2021). It is anticipated that whole building commissioning will continue into the future, to ensure that commissioning focuses on the general user experience and value drawn from all the functionalities, modules, and utilities of the deliverable engineering package. It is worth noting that whole-building commissioning is closely associated with integrated commissioning, which focuses on centralizing the commissioning process and ensuring that all functionalities and modalities are checked sufficiently to guarantee higher performance and resource utilization (Fischer, 2021).

Whole building commissioning has become a norm in the construction sector because of the concept of asset management. When buildings are constructed, they are considered the owner's assets, and their management until the assets is sold to the next client is key throughout the lifecycle of the building. This concept has seen whole building commissioning attracting the use of continuous improvement for delivery of superior and high functionality structures (Fischer, 2021). The complexity of current problems facing the construction sector necessitates adopting forensic science and complex problem-solving alternatives. There is a need for the commissioning team to focus on adopting the current trends that empower commissioning services to guarantee that buildings will remain appealing with new structures and trending utilities. This is to guarantee that the building would have sufficient resource utilization and high efficiency (Fischer, 2021). In this case, whole building commissioning seeks to ensure that the structure operates as a successful single entity: having renewable energy and resources, audio-visual resources, cellular capability, fire life safety, enclosure, information technology, and high air monitoring and quality.

It is worth noting that whole building commissioning is a system-based approach and thus seeks to ensure that integration and connectivity between modules work efficiently (Fischer, 2021). The system approach helps to focus on every functionality and user need, which guarantees the overall success

of the project in delivering value to the users and project owner. The system approach has enabled for clear detection of discrepancies in requirements as well as risks and possible bottlenecks in the delivery of a high-quality project. This has helped engineers focus on the final deliverable right from the planning stage, where they start documenting the milestones and deliverables to be attained for success (Fischer, 2021). This holistic approach to project execution has helped engineers to deliver buildings and structures that meet industry standards and requirements.

Whole building commissioning focusses on reducing the owner's risks and improve operational perspectives (Fischer, 2021). Whole building commissioning seeks to ensure that modern and super modern buildings have extra utilities and functionalities that users crave for such as Wi-Fi connectivity and signal availability. Whole building commissioning is set to continue into the future because of the concept of integration and centralization, which makes it easy to manage budgets, planning, and activities. Whole building commissioning will also continue because of its value in reducing operation and running costs (Fischer, 2021). Whole building commissioning is also beneficial because of better testing and tracking of discrepancies in modules and processes. This enables for delivery of a high-quality engineering product. Whole building commissioning enables for a holistic view of the engineering deliverable, which guides in converging synergies for the purposes of delivering a high-quality product.

7. ONGOING COMMISSIONING AND OPTIMIZATION

Although commissioning (Cx) was initially a routine procedure, modern and future approaches to the entire concept of commissioning would be ongoing commissioning (OCx) (Fischer, 2021). Ongoing commissioning focuses on guaranteeing the functionality and value of the building or structure throughout its use and operation. This type of commissioning does not single out the handover process to the client but transcends across periods and times throughout the use and operation of the structure or building. This approach to commissioning seeks to guarantee high-quality service delivery by structures. Ongoing commissioning is a sustained continuous phase of monitoring and diagnostics to determine the errors and rectify the situation for better service delivery. In general, ongoing commissioning is not a one-time process, but one that requires lengthy time to implement through various project stages. It is worth noting that ongoing commissioning is guided by the owners' current facility needs and requirements (Fischer, 2021). As such, buildings and structures need functionality and services that would facilitate efficient operations through all seasons and contexts. As such, changes in climate, weather, humidity, temperature, and many other things would need constant evaluation, monitoring, and altering to suit the project owner's requirements.

Ongoing commissioning focuses on the long-term performance results and thus uses direct digital controls to ensure high-performance standards. It is also worth noting that the construction sector is shifting further into information management science (Fischer, 2021). This is exhibited through data acquisition, the use of hardware and software solutions, as well as data storage and analytics. There is a shift into the use of commercial software to verify performance and troubleshoot project anomalies. Data analysis continues to shape decision-making and accountability in the construction process. According to Singh and Anumba (2023), the use of data analytics in construction has helped to increase the performance of buildings and structures by about 15%. It is worth noting that use of ongoing commissioning can increase the sophistication of the commissioning process. This is because it can necessitate use of more machines and tools to guarantee an effective commissioning process. Singh and Anumba (2023) reveal that ongoing commissioning is the best-suited commissioning approach because it offers project owners reliable and timely information on how they can mitigate risks. It is worth noting that ongoing commissioning highly utilizes monitoring-based commissioning (MBCx), which focuses on testing and determining process and system-based risks and strengths (Fischer, 2021). Fault detection in monitoring-based commissioning and continuous use of diagnostic mechanisms have helped to enhance equipment life, and energy savings, and enabled lower costs (Singh & Anumba, 2023). It is worth noting that ongoing commissioning is selected as a futuristic approach to commissioning because it is predictive and could help to overcome potential future problems.

Ongoing commissioning is a necessity because of the continuous advancement in technology and new building theories that are changing building design, building utilities, green energy initiatives, and many other upcoming factors (Singh & Anumba, 2023). Due to this, ongoing commissioning is expected to increase in the commissioning process. This is because of the benefits ongoing commissioning offers to the engineering process. Ongoing commissioning helps to reduce overall management and operation costs, as well as increase accountability and effectiveness (Fischer, 2021). Ongoing commissioning is also aligned with whole building commissioning and budget integration, which focus on centralization of commissioning tasks and activities.

8. ENERGY AS A SERVICE (EAAS)

This is another important trend that is expected to dominate the construction sector into the future. This is because of the perennial challenge of energy management and requirements, which has put engineers to task in identifying the most optimized solutions of energy sources for buildings and structures. Energy as a service (EaaS) focusses on the use of financial models provided by third parties and used to manage the design, construction, and maintenance of energy systems in buildings and structures (Singh & Anumba, 2023). In this case, the project owner pays for the service to the service provider and does not buy the entire infrastructure needed for the energy service. In this case, energy is a service and not part of the infrastructural needs for the project owner. Energy management is a complex entity because of the high initial investment, which makes many project owners to adopt for energy as a service.

It is worth noting that project owner's benefit by using energy as a service. This is because they avoid the high initial infrastructural costs, maintenance costs, and upgrade costs, which can result in low costs (Westminster Forum Projects, 2017). Energy as a service is becoming a favorite approach to energy management for most schools, hospitals, municipal buildings, and institutions. This is owing to the many benefits associated with subcontracting power management as a service. Implementation of energy as a service has enabled for development of the combined heat and power system (CHP), which generates electricity on site and heat that is used to produce hot water and space heating. The CHP uses natural gas or other fuels to produce electricity while the waste heat produced is used to warm buildings or water. In this case, energy source is not viewed as a utility that needs payments at the end of every month, but rather a service that must be run using few resources (Westminster Forum Projects, 2017). This approach in the management of energy in buildings has enabled hospitals and institutions to reduce their energy consumption, carbon emissions, as well as costs associated with energy use.

Based on the mentioned benefits of using energy as a service, it is clear that this trend would continue into the future. This is because of its cost effectiveness in management of power consumption, which results in successful engineering projects. Energy as a service is prone to dominate all commissioning projects because of the reduced operational overheads associated with power installation and management (Westminster Forum Projects, 2017). This would help commissioning projects to be more efficient and successful in meeting carbon emission requirements and quality standards. Efficiency in energy use is a critical aspect in the 21st century since energy efficient buildings and structures translate to low running and operational costs.

9. ADOPTION OF COMPREHENSIVE COMMISSIONING

Comprehensive commissioning refers to a new approach to the commissioning process that focusses on the holistic system, enabling for a broader view of the whole commissioning process (Fischer, 2021). Comprehensive commissioning is closely related with whole building commissioning and focusses on the systemic view of the building or structure. Comprehensive commissioning is important in the architectural sector because of the increase in natural disasters, which necessitate alternative measures to mitigate such disasters and protect lives and property. Natural disasters such as earthquakes, floods, wildfires, pandemics, hurricanes, and many others necessitate appropriate consideration of many factors for smooth execution of the commissioning process (Fischer, 2021). The occurrence of such natural disasters requires appropriate mechanism to guarantee the safety and security of individuals.

It is worth noting that implementation of comprehensive commissioning has various benefits to projects. The first benefit of comprehensive commissioning is cheaper costs, which is achieved due to a system-based approach to project management (Fischer, 2021). Adopting a systemic approach to evaluation of risks, engineering processes, resource allocation, and personnel management has helped engineers to discover how to allocate resources to processes and systems. This has resulted in low wastes, which translates to low costs. Another benefit of comprehensive commissioning is better planning of the entire engineering project (Fischer, 2021). Proper planning and visibility of process steps is essential in guaranteeing successful completion of the project.

Comprehensive commissioning is also beneficial because it enables for more collaboration among commissioning team members. This is because comprehensive commissioning requires that all departments and units work together and amalgamate all their resources and equipment for a systemic view of the project (Fischer, 2021). The commissioning team is required to work jointly to ensure that there is success in the execution and delivery of the project to the project owners. Comprehensive commissioning enables for early detection of errors and bottlenecks, enabling for quick solutions to such challenges.

10. USE OF REGULATION AND ESG REPORTING

Management of energy-related emissions from buildings is a critical issue in the 21st century. Every country is keen to record low carbon emissions per period and are seeking better approaches of providing fuels and power (Fischer, 2021). For proper power management, the government introduced the Building Performance Standards (PBS), which outlines all the requirements and standards that need to be met for a successful engineering structure. It is worth noting that in the United States alone, buildings contribute up to 35% of energy related carbon emissions. This is a high percentage and there is a need to adopt new trending technology that guarantees lower energy-related carbon emissions.

Adopting environmental, social, and governance (ESG) reporting is critical to the building owners because it helps them achieve the required industry standards (Reform, 2015). There is a need for the project owner to ensure that the site meets all environmental requirements, social requirements, and governance structures. ESG reporting enables engineers to track the project progress in meeting all social, governance, and environmental concerns. It is worth noting that companies that meet ESG reporting have a higher likelihood of better performance and higher number of investors as compared to those that do not comply with ESG requirements. As such, adherence to ESG requirements is critical in attaining engineering systems that offer value and sustainability to the project owner and the users.

11. USE OF GRID-INTERACTIVE EFFICIENT BUILDINGS

Grid-interactive efficient building (GEB) has become a major trend in the construction sector, and it is considered a smart trend in building commissioning. GEB has become a major trend because of the industrial shift towards the use of renewable energy sources and green energy initiatives, which has necessitated smart transition mechanisms from grid power use to renewable energy sources without affecting operations (Reform, 2015). The GEB has helped institutions to remain operational even during change of power supply from grid supply to local renewable energy supply. The use of GEB has facilitated easy integration between grid supply and wind and solar power sources. It is worth noting that GEB offers advanced technology and layout structures that enable for better battery energy storage and smart building controls. GEB systems have enabled for demand response and regulation of frequency to ensure that energy supply is consistent with requirements. There are many research and development initiatives seeking to enhance the efficacy and effectiveness of GEB systems (Reform, 2015). There is growing number of utility pilots and demonstration projects geared at ensuring that GEB systems are upgraded to be efficient and effective.

The use of GEB systems has enabled for collection and storage of excess power in energy storage facilities. As such, GEB systems have enabled for effective management of power, where excessive energy is stored during low-demand periods and used during high-demand periods (Reform, 2015). This has enabled for effective management of energy usage in public institutions. It is worth noting that GEB systems have enabled for cheaper power generation, storage, and usage. The possibility of storing power has helped many institutions to remain operational even whenever there are disruptions in grid power supply. GEB systems have also enabled for ancillary services to the grid. As an example, GEB systems have enabled for reactive power support, which helps to maintain frequency and voltage of the grid (Reform, 2015). This ensures that power supply is consistent and reliable. Frequency regulation also helps to balance between supply and demand. Another benefit of GEB systems is the ability to substitute the need for another power plant or expensive power infrastructure.

It is also worth noting that GEB systems have enabled for easy integration of the charging system of electric vehicles (EVs) into the system (Reform, 2015). This has enabled for easy handling of the charging of EVs and enhanced integration of various power equipment. The changing of EVs through GEB systems has reduced their impact on the grid. The GEBs use control systems and algorithms to control all processes, which has ensured a smooth transition when shifting from grid supply to other power supplies. In general, the use of GEBs has enabled for low-carbon electricity and low-cost power. This has helped companies and institutions to save on the costs of power installation as well as maintenance. It is anticipated that going into the future, more of GEB systems will be invented to help in enhancing power related operations (Reform, 2015). There is a need for caution when developing a scalable and integrated power supply system because of the risks involved and there is a need to use expert personnel to install and manage.

12. USE OF INDEPENDENT DATA LAYER

Considering that the future of commissioning is full of integration with the Internet of things, it is necessary that all commissioned structures have plans and infrastructure for data storage and management (Reform, 2015). This is enabled through the adoption of the independent data layer

(IDL). This is an institutional database and its network that enable for easy data collection, analysis, and sharing. The independent data layer also enables for easy access and management of various modules and functionality on building structures such as HVAC systems, BAS controls, and many others.

The use of the independent data layer has many benefits to engineering structures because of the centralization of all data management activities under one entity (Reform, 2015). The IDL systems enable for the capture of data from various sources as well as the safe storage of this data in databases, enabling for easy control, tracking, and automation of functions in real time. It is worth noting that the IDL enables for accurate data storage and reporting, which aids building users in making informed decisions. Such things as sensors, surveillance systems, and risks assessment initiatives benefit from availability of an independent data layer (Reform, 2015). The performance of buildings is pegged on the availability and use of data and attainment of performance metrics. Buildings and engineering structures are supposed to meet the required risk threshold to guarantee reliability and resiliency in service delivery. It is worth noting that the IDLs also enable buildings have easy management of occupant comfort, indoor air quality, and energy consumption.

An important element of IDLs is their capability to centralize data in databases, thereby enabling for easy tracking and analysis of trends and conclusions from data (Reform, 2015). Centralization of data management in buildings and structures has enhanced the security of buildings, and the management of services such as surveillance. An important aspect to consider when developing the IDLs is security, which must be evaluated to ascertain that hackers cannot take control of the data layer.

13. HEALTHIER FUTURES AND CONNECTED FUTURES

In today's technological and highly interconnected world, all individuals are after connecting with others through both internet connectivity as well as outdoor sessions (Reform, 2015). Healthy trends have become a norm and buildings should highly consider designating areas for relaxation, hobby development, and leisure time. It is anticipated that health and connectivity will dominate the engineering sphere in guiding the design of buildings and structures. Health and connectivity are major trends in construction commissioning since they translate to happier communities (Reform, 2015). The need for human connectivity and healthier futures puts engineers to task in designing buildings and structures that enhance human happiness by offering the needed services that boost health and connection.

Health is a priority for all people because healthy bodies translate to happier lives. This has pushed many individuals to consider regular gym exercises to remain fit and healthy (Reform, 2015). This is a trend in many cities and building structures need to have recreational spaces where individuals can engage in exercise or other fun activity. In addition, engineers need to design buildings that enable for efficient air circulation, humidity control, air pollution management, and general monitoring and control of the internal environment. This is to guarantee the safety and health of the occupants of such structures. Closely linked with health is the issue of accessibility of the building. Buildings are required to have multiple access points that can accommodate those using wheelchairs and other support systems for movement. Accessibility of buildings is also a necessity because of cases such as fire evacuation and emergency evacuation, which might necessitate alternative modern routes for management (Reform, 2015). Accessibility of buildings also aids in ensuring that stretchers and other caricatures can be needed during emergency health services can gain access of the building. In order to guarantee great health of occupants, engineers need to consider balancing all health needs to ensure success in utilization of buildings.

Connectivity among humans is a necessity at all times. Humans thrive through mutual connection and cooperation. In light of this, there is every need for commissioned structures to have spaces that enable for congregation or connectivity among people (Reform, 2015). There is a need to consider allowing enough spaces for gatherings and convergence of activities. Engineering structures need to have entertainment halls and spaces to ensure that people remain connected through hobbies and other recreational activities. This is to boost community development and to enshrine societal norms in the upcoming generation. There is need for engineers to ensure that buildings are fitted with the latest satellite connectivity for television broadcasting and internet connectivity services for higher connectivity of occupants (Reform, 2015). There is also a need to consider setting up facilities such as tap water, seats, and other utilities in open spaces that are meant for public forums.

CONFLICT OF INTEREST

The authors declare that they do not have any conflict of interest.

REFERENCES

- Fischer, L. (2021). The future of building commissioning. *Consulting Specifying Engineer*. <https://www.csemag.com/articles/the-future-of-building-commissioning/>.
- Pacific Northwest National Laboratory. (2005). *Beyond Commissioning the Role of Automation*. New York: Elsevier.
- Reform. (2015). *The Future of Commissioning*. London: Reform.
- Singh, J., & Anumba, C. J. (2023). Building commissioning process and documentation: A literature review and directions for future research. *International Journal of Construction Management*, 75–85.
- Westminster Forum Projects. (2017). *The Future for Specialised Services and Commissioning*. New York: Westminster Forum Projects.