

# Adaptability in Energy Efficient Office Building Design

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## To cite this article:

Noah Gethsemane Akhimien, Kingsley Okechukwu Dimuna. Adaptability in Energy Efficient Office Building Design. *International Journal of Architecture, Arts and Applications*. Vol. 8, No. 3, 2022, pp. 106-111. doi: 10.11648/j.ijaaa.20220803.12

**Received:** May 29, 2022; **Accepted:** June 20, 2022; **Published:** July 28, 2022

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**Abstract:** Office Buildings are expected to provide adequate support to different clerical operations considering CO<sub>2</sub> emissions and adaptable spaces. However, most office buildings fall short of these requirements. This study aimed to promote Adaptability in energy-efficient office buildings. Hence, reducing CO<sub>2</sub> emissions as it relates to climate change. Flexibility is a vital requirement in office operations, but most tenantable office buildings lack this, especially in fitting workspace into different work configurations. The research method was based on case studies using a descriptive method of data analysis to conduct qualitative and quantitative research in investigating patterns of adaptable office spaces considering eco-friendly energy sources for office operations. This allowed the study to evaluate the drawbacks of existing office buildings and to recommend the best strategies and flexible layouts. Studies revealed that most office buildings were not adaptable to different work settings traceable to dedicated office layouts to specific functions. The research recommended the best office arrangements/templates for effective operations, adaptability, and minimizing CO<sub>2</sub> emissions. Consequently, office buildings should be responsive in providing flexible space and saving energy. To accomplish this development, the building must benefit from an integrated design approach that focuses on meeting a list of objectives that addresses CO<sub>2</sub> emissions while at the same time offering users increased working satisfaction, productivity, and greater flexibility in different work conditions.

**Keywords:** Adaptability, Buildings, Energy, Efficiency, Office

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## 1. Introduction

An adaptable building is a building that has been designed, constructed, and maintained with the thought of how it might easily be altered to prolong its life, for instance by addition or contraction, to suit new uses or patterns of use [1]. This could also mean flexibility in buildings designed to allow easy rearrangement of their internal fit-out and arrangement to suit the changing needs of occupants [1]. In this context, the Adaptability of buildings is the flexibility of an office building to change its configuration to suit different work conditions as it relates to tenants' needs. According to Gerwin, flexibility is usually perceived as an adaptive response to environmental uncertainty [7]. More specifically, it reflects the ability of a system to change or react with little penalty in time, effort, cost, or performance [14]. Hence, flexibility may be a proactive attribute designed into a system, rather than a reactive behavior that may result in a detriment to time, effort, cost, and performance [10]. Office

buildings are driven by user types, such as investment banks, professional firms, or high-tech companies [12]. The needs of these users normally dictate the floor size, concept, and marketable location of the building.

On the other hand, energy efficiency in office buildings forms the basis of tenants' productivity, choice of equipment, and services. CIBSE Guide A asserted that the indoor environment of any building determines the health, productivity, and comfort of its occupants as buildings are used to provide the microclimate required for human existence [5]. Therefore, an office building that is adaptable and runs on low energy provides a better chance of using more office equipment and enjoys a wide range of users' patronage.

## 2. Methodology

This study aimed to promote adaptability in energy-efficient office buildings. The study conducted a review of adaptable

office spaces. This was followed by identifying and categorizing office types into space types highlighting functional descriptions which allowed the study to investigate patterns of adaptable office spaces considering eco-friendly energy sources for office operations while maximizing bioclimatic design strategies. It further evaluated the drawbacks of existing office buildings and finally recommended best practices and possible flexible layouts.

### 3. Literature Review

According to Edmonds & Gorgolewski, adaptable buildings incorporate flexible configurations at the design and construction stage, hence, future changes can easily be made and with minimum expense to meet the evolving needs of occupants [6]. Adaptability has been classified as capability and flexibility as competence, where capabilities are derived from lower-level competencies [13]. It means designing a building to allow its hierarchical layers to change, each in its timescale. Incorporating adaptability into a building during initial construction saves time, money, and inconvenience when changes are later required. Addis and Schouten consider that a flexible building has been designed to allow easy rearrangement of its internal fit-out and arrangement to suit the changing needs of the occupants [1]. Hence, the open office layout is widely used to achieve adaptable spaces in office settings. According to Borzykowski, about 70% of US offices are open plans and very few have readopted traditional spaces with offices and doors [4]. Open office buildings seek to respond to users' preferences by offering the flexibility needed for the adaptation of individual units over time. Buildings should be designed to enable sub-systems to be installed or changed with a minimum of interface problems. This is usually achieved by the separation of a 'base-building and its interior 'fit-out' [8].

The open plan relies on ergonomics to help make employees productive as possible.

This office type has no walls dividing desks, no cubicles,

and no individual offices. These are primarily associated with the requirements for upgrading and maintaining office buildings throughout their life and enabling internal fit-out changes in high turnover-internal environments such as retail facilities or offices. Slaughter identified that the cost and time of refurbishments are reduced if buildings are designed for flexibility [12]. However, there are shortcomings in some office layouts as identified by Professors at the University of Sydney. They found that nearly 50% of people with a completely open office floorplan, and nearly 60% of people in cubicles with low walls, are dissatisfied with their sound privacy, but just 16% of people in private offices complained the same [4].

The design technology for creating energy flexibility in office buildings through bioclimatic considerations can be utilized in increasing the energy efficiency of the building, CO<sub>2</sub>-emissions reduction as well as a higher uptake of renewable energy sources.

### 4. Discussions

There are several conditions for any system to be energy efficient. It is a sum of factors for the system to be energy efficient which may include equipment, resources, maintenance, recycling, responsive buildings, and a natural environment. Some of these factors may include aspects of cost, energy generation predictions, climatic data, compliance with regulations, and the operating agreement. It is also important to engage renewable energy resources such as photovoltaic systems and the use of low-energy equipment for an energy-efficient office building. This will save costs and reduce pollution.

The primary aim of an office environment is to support its users in undertaking their job at minimum cost and maximum satisfaction. With different people performing different tasks and activities, it is not always easy to select the right office spaces. To aid decision-making in workplace and office design, office spaces can be distinguished into three different types: workspaces, meeting spaces, and support spaces.

*Table 1. Office type, space type and description [9].*

Sn	Office type	Space type	Description
1.	Open office	Workspace	An open workspace for more than ten people - frequent communication and little concentration.
2.	Team space	"	A semi-enclosed workspace for two to eight people - teamwork
3.	Cubicle	"	A semi-enclosed workspace for one-person - medium concentration and medium interaction
4.	Private office	"	An enclosed workspace for one-person - high concentration
5.	Shared office	"	An enclosed workspace for two or three people - semi-concentrated work and collaborative work
6.	Team room	"	An enclosed workspace for four to ten people – confidential, frequent internal communication.
7.	Study booth	"	An enclosed workspace for one person - short-term activities which demands concentration or confidentiality
8.	Work lounge	"	A lounge/informal workspace for two to six people - collaboration and/or allow impromptu interaction
9.	Touch down	"	An open workspace for one person - little concentration and low interaction
10.	Small meeting room	Meeting spaces	An enclosed meeting space for two to four persons - formal and informal interaction.
11.	Large meeting room	"	An enclosed meeting space for five to twelve people - formal interaction.
12.	Brainstorm room	"	An enclosed meeting space for five to twelve people - brainstorming sessions and workshops.
13.	Meeting point	"	An open meeting point for two to four persons - ad hoc, informal meetings.
14.	Filing space	Support spaces	Open or enclosed support space for storage of frequently used files and documents.
15.	Storage space	"	Open or enclosed support space for storage
16.	Print and copy area	"	An open or enclosed support space with office equipment
17.	Mail area	"	An open or semi-open support space where employees can pick up or deliver mail.
18.	Pantry area	"	An open or enclosed support space where people can get coffee and tea, soft drinks and snacks.

Sn	Office type	Space type	Description
19.	Break area	“	A semi-open or enclosed support space where employees can take a break
20.	Locker area	“	An open or semi-open support space where employees can store their personal belongings.
21.	Smoking room/area	“	An enclosed/open support space where employees can smoke a cigarette.
22.	Library	“	A semi-open or enclosed support space for reading of books, journals and magazines.
23.	Games room	“	An enclosed support space where employees can play games
24.	Waiting area	“	An open or semi-open support space where visitors can be received and can wait for their appointment.
25.	Circulation space	“	Support space, which is required for circulation on office floors, linking all major functions.

There are many ways of arranging the space in an office as it varies according to work type. Managerial functions and the culture of specific companies can be more important. Considerations include, how many people will work within the same room. In one instance, each worker will have their room; in the other instance, a large open plan office can be made up of one main room with tens or hundreds of people working in the same space. In open-plan offices, workers are put together in the same workspace which can improve short-term productivity. There is also a loss of privacy and security which can increase the incidence of theft and loss of company secrets. A compromise between open plan and separate rooms is achieved by the cubicle desk arrangement which to some extent solves visual privacy but sometimes fails on acoustic separation and security.

Building services are major considerations in office buildings as it defines the layout to a large extent. However, adaptable office spaces need to also integrate adjustable service points, such as electrical installations, light fixtures, etc. Webb et al's research examined how building services can be designed to accommodate change [15]. The study concluded that 'by utilizing reusable service components, facilities managers may be able to increase the adaptability of both new and existing office buildings and reduce the financial impact of change'. Slaughter further suggests that the need for changes to a building is increasing with rising consumer expectations, the increasing rate of technological progress, and the intensity of competitiveness [11]. Studies indicate that workers are 15% less productive, have immense trouble concentrating, and are twice as likely to get sick in open working spaces [4]. A study of an office building at Axiom Law in New York revealed that a cluttered and claustrophobic office partitioning system prevented employee inspiration, motivation, and poor voice communication [3]. This hindered air movement resulting in inefficient means of ventilation further increasing cost, and environmental hazards including CO<sub>2</sub> emissions. As much as open office spaces remain an effective way of achieving flexibility, poor use of the strategy could result in a lack of privacy, distractions most especially when office activities are carried out in the wrong workspaces as seen in Facebook's California office, the office emphasized the lack of privacy as there are missing defined office partitioning system [3]. This enabled noise to travel across the office.

Private office spaces on the other hand are most rigid but users enjoy privacy although it may not be best for collaboration. Private offices are not flexible to change and tend to consume more energy due to the provision of separate facilities. This can make the office building energy inefficient

and could increase CO<sub>2</sub> emissions. Some of the needs for adaptability and flexibility are well understood and office building design solutions to address these needs are well established. For example, office partition systems designed to accommodate changes required for the internal configuration of offices are ubiquitous. Services and IT systems have relatively short lives and are installed in accessible floors and ceiling systems facilitating their replacements. Hence, providing raised floors and suspended ceilings will provide flexible service spaces underneath and above.

Concerning climate change, there are changes to office building regulations that aim to reduce the building's operational energy requirements. The environmentally friendly office building design is highly emphasized with the provision of alternative lightening solutions including daylighting, enhanced energy management systems with energy-efficient equipment, economical space use to reduce energy consumption through utility sharing, proper ventilation systems in buildings including natural ventilation, and the use of open-office plans for increased office space flexibility [16].

Seven office buildings were studied in Birmingham, they include Alpha Building, The Cube, Baskerville House, Concord Center, Fort Dunlop, John Hand Building, and The McLaren Building. The study revealed that most of the offices consisted of adaptable spaces that have been tailored to serve the needs of various occupants. Typically, the office spaces which measured approximately 245 square meters per segment were fitted with flexible lighting and electrical service points for easy adjustments. Some of the offices had considerations to improve energy efficiency, such as lighting, heating, and cooling sensors, however, some of the building energy management systems were not optimized according to office hours. In addition, some of the spaces could save energy by using common services where possible such as shared HVAC systems, as well as segmenting services such as lighting, so they are only in operation when spaces are occupied. The office space arrangements can be described under the following layouts: semi-separated, separate, semi open, alternate, leader workgroup, sectional workgroup, supervisory workgroup, cubicle, and adaptable layouts.

#### *Office Layouts*

**Semi separated layout:** In this layout, dwarf partitions separate open plans to reduce distractions and integrate common services and technology. See figure 1. Semi separated layout. Separate office spaces are also very useful where confidentiality and privacy are needed. This type of office space is usually enclosed with partitions.

**Semi open layout:** Semi open offices provide some levels

of privacy where it is necessary to maintain a balance between open and closed offices. See figure 8. Semi open layout.

**Alternate layout:** A zigzag pattern locking common services together is an ideal way of distributing noise in an open office. Workstations are positioned to also reduce distraction. See figure 3. Alternate layout.

**Workgroup layout:** In this arrangement, workers usually engage in similar projects sometimes accompanied by a team leader or supervisor. Sometimes a wide work desk could be used such as in meeting rooms. See figure 5. Supervisory workgroup layout, figure 6. Leader workgroup layout, figure 7. Sectional workgroup layout.

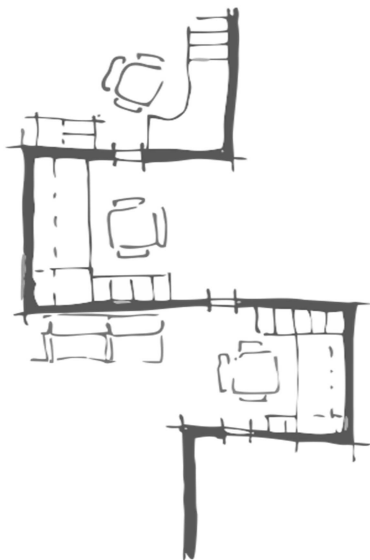
**Semi-private layout:** This is like the semi-separated layout; the major difference is that there is less distraction since partition walls usually extend to the ceiling. It is ideal in offices where little privacy is required.

**Cubicle layout:** Workstations are separated by partitions in a common office space. See figure 2. Cubicle layout.

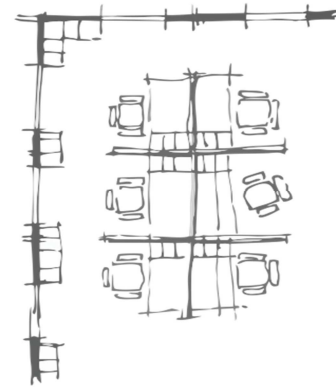
**Adaptability:** Office spaces should be designed to include features such as a raised floor and suspended ceiling for services such as power, data, voice, and HVAC. Mobile workstations should also be accommodated. Alternatively, movable partitions cater for changes in equipment, employee, and storage needs. See figure 4. Adaptable layout.

**Comfort and safety:** The health, safety, and comfort of workers are very important. Hence, the office space type should be properly ventilated and fitted with lighting, occupancy, and indoor air quality sensors/monitors.

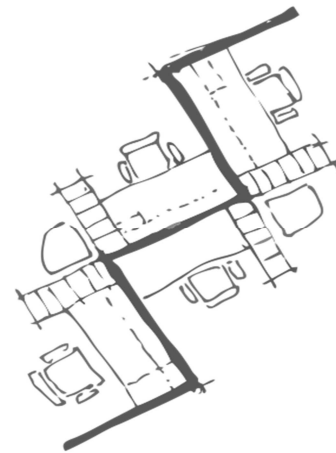
**Energy Efficiency:** Energy costs increase with higher reliance on artificial technology. Natural ventilation and daylighting are key considerations; the installation of high-efficiency HVAC equipment should as well be considered. Flexible office spaces can cut down CO<sub>2</sub> emissions since users are not restricted to a fixed method of operations, hence buildings can be operated using both artificial and natural means.



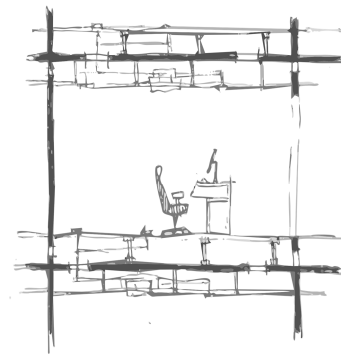
**Figure 1.** Semi separated layout.



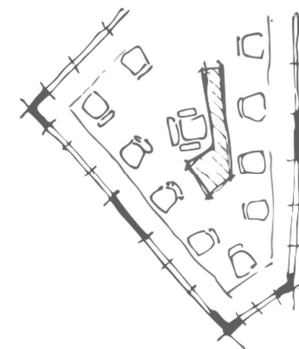
**Figure 2.** Cubicle layout.



**Figure 3.** Alternate layout.



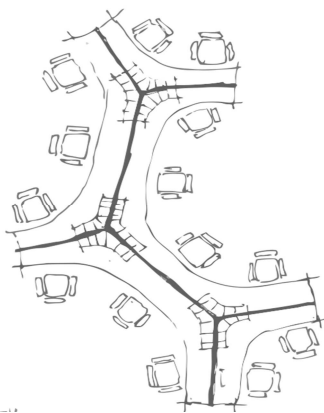
**Figure 4.** Adaptable layout.



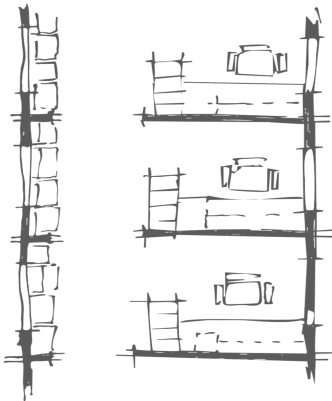
**Figure 5.** Supervisory workgroup layout.



**Figure 6.** Leader workgroup layout.



**Figure 7.** Sectional workgroup layout.



**Figure 8.** Semi open layout.

Figures 1-8: Office layouts for adaptability.

In improving productivity and privacy of workers open offices can break floor space with huddle rooms or movable barriers such as rolling boards which can also be used as marker boards. Audible distractions can also be dampened by ceiling fixtures like acoustical clouds, fabric surfaces, and sound-masking speakers [2]. Office buildings can be adaptable and eco-friendly if the design integrates movable fixtures and maximizes natural elements such as daylighting and natural ventilation in reducing building running costs and CO<sub>2</sub> emissions.

## 5. Conclusion and Recommendations

Office layouts are usually influenced by the administration, workflow, and type of clerical activity performed. Therefore, in meeting the need of a wide spectrum of users, it is paramount to experiment with designs that provide a mix of cubicles, open workstations, private offices, and group workstations. It was concluded that there is a need for office buildings to have more flexible spaces, adaptable office equipment, and materials, built-in services, etc. It is important that energy management systems are in place to monitor and optimize building services such as lighting, and HVAC systems. It is beneficial to use common energy services within spaces where possible to reduce CO<sub>2</sub> emissions in addition to integrating dynamic monitoring sensors for optimal performance. The office space should be a flexible environment that integrates technology, safety, comfort, and energy efficiency in providing a productive, cost-effective, eco-friendly, and aesthetically pleasing work environment. Hence, the study proposed some office design templates (figures 1-8) to promote adaptability and efficiency in office buildings. These typical features of office space types should include the following applicable office design recommendations as outlined below.

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