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Perception of Construction Industry Players on Carbon Dioxide Reduction through Planning and Design Stage in Project Life Cycle

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Abstract: The construction industry played a considerable role in rising carbon dioxide emissions. Construction industry players did not properly handle the project life cycle, which brings in carbon dioxide emissions that indirectly contribute to global warming and climate change. So, the carbon dioxide emission become more challenging due to construction's planning and design stage in project life cycle. The objectives of the research are to identify the perception of construction industry on carbon dioxide reduction through planning and design stage in project life cycle and to purpose carbon dioxide reduction strategies through planning and design stage in project life cycle. The research has been implemented by quantitative method which a questionnaire survey was distributed to construction players like architect, engineer, quantity surveyor and project manager from the state of Johor Bahru and the survey was obtained from 55 respondents. Statistical Package for Social Science (SPSS) were analyzed the data collected. The findings guide efforts to reduce the carbon dioxide emissions in construction industry by assisting construction key players in providing a better strategy through planning and design stage in project life cycle. Construction industries strive towards solving the problem of carbon dioxide emissions to decrease environmental impacts and become environmentally friendly. In conclusion, the study is completed successfully as all objectives are achieved.

Keywords: Carbon dioxide reduction, Planning and design stage, Project life cycle

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1. Introduction

The construction industry is one of the industries that has the biggest environmental effect and contributes to global warming and climate change, since it consumes significant quantities of materials, raw materials, and energy, which is primarily derived from non-renewable (Mercado Burciaga *et al*.,2019). The construction industry is strongly reliant on natural resources and produces a significant amount of carbon dioxide emissions. As a reason, it is vital of the whole sector to aim toward planning and design stage that minimizes environmental consequences (Trinh *et al*., 2017). According to S. Thomas Ng *et al*. (2012), the planning and design stage in project life cycle is critical for reducing carbon dioxide emissions since choices made at this stage have an impact on operational efficiency. Therefore, this study aims to identify perception of construction industry players on carbon dioxide reduction through planning and design stage in project life cycle.

Nowadays, the threat of human-induced climate change has grown significantly serious and severe in recent years due to growing atmospheric concentrations of greenhouse gas (GHG) emissions linked to human energy use. Due to ocean thermal expansion, global warming is causing a number of environmental changes, such as the melting of land ice and rising sea levels (S. Thomas Ng *et al*., 2012). Buildings emit a significant quantity of carbon dioxide over their lifetime, intensifying greenhouse-gas impacts and posing a danger to human and other species existence (Kun Lu *et al*., 2019). Energy released throughout the beginning of the project, construction phase, operating phase, and demolition phase of the project results in CO2 emissions. The whole environmental impact of building systems and materials is evaluated using contained energy since energy usage releases CO2, which increases greenhouse gas emissions. (Agung Wibowo *et al*., 2018).

As a result, the carbon dioxide released over the building life cycle must be carefully monitored. The planning and design stage is critical for reducing carbon dioxide emissions since decisions made at this stage have an impact on operational efficiency. A smart planning and design should not only maximize the potential for emission reductions during the project life cycle of the building, but also remove the necessity for costly and disruptive carbon dioxide reduction measures during the post-occupancy period (S. Thomas Ng *et al*., 2012).

2. Literature Review

2.1 Definition of Project Life Cycle

According to Egeland (2020), the construction project life cycle is important because it may assist a project manager in keeping track of and organizing work in a timely and effective way. There are 5 stages in the project life cycle including, initiation, project planning and design, execution, performance and monitoring, and closure. Indeed Career Guide (2021) also stated that the project life cycle refers to the sequence of activities that must be completed in order to complete the construction project. To begin with, it serves as a road map for the full process of executing a project, from conception to conclusion. It aids with the timely and effective completion of building projects by keeping them well-organized.

2.2 Definition of Planning and Design Stage

In the planning stage, the project solution is developed in as much detail as possible, define the project's purpose and scope, conduct feasibility studies, select land, or investigate site conditions, and the steps necessary to achieve the project's objectives and goals are planned (Mushtaq, 2014). According to Agung Wibowo *et al*. (2018), the planning stage is the most important and requires a significant amount of time and personnel because it lays the groundwork for the entire project. Next, design, in its broadest sense, is the communication of an idea or the resolution of requirements through tools like drawings, plans, specifications, and models. Mushtaq (2014) defined that schematic design establishes

the relationship between the various components of the project, whereas design development specifies exact dimensions and locations of various structural elements, earthworks, mechanical systems, and other components, according to detailed calculations and drawings.

2.3 Roles and Responsibilities of Construction Players in Planning and Design Stage

According to Am Theron (2018), Understanding how a construction site should operate depends on being aware of the various roles and responsibilities of the various role players involved in a typical construction project. A construction site may be highly intricate not just in terms of the technical intricacy involved, but also in the fact that a variety of professional specializations must work together as a team to achieve the intended result. Table 2.1 show the roles and responsibilities of the construction players in planning and design stage.

Table 1: Roles and responsibilities of construction players in planning and design stage

No	Construction Player	Role and Responsibilities of Construction Players in Planning and Design Stage
1	Architect	• Project discussion. - To develop budget, site features, safety, and planning. • Preparation of drawings. - To develop conceptual design. - To develop detail design and analysis.
2	Engineer	• To develop detail design. • To develop drawings with detail elements.
3	Quantity surveyor	• Plans and generate bills of quantities • To produce cost estimation / cost planning.
4	Project manager	• Clearly understanding the goal of the project. • Scheduling and planning in construction project.

2.4 Carbon Dioxide Emissions

Based on Eurostat Statistics Explained (2017), carbon dioxide is a colorless, odorless, and non-poisonous gas produced by the burning of carbon and by living organisms' breathing. It is a kind of greenhouse gas. Emissions are defined as the release of greenhouse gases and their precursors into the atmosphere over a specific geographic area and time period. From the World Bank (2020), fossil fuel burning, and cement manufacture are the primary sources of anthropogenic carbon dioxide emissions. Natural gas and coal both emit carbon dioxide in burning, but oil releases around 50 percent more carbon dioxide than natural gas for the same amount of energy consumed. For every metric ton of cement produced, around 0.5 tons of carbon dioxide are emitted into the atmosphere. A significant rise in atmospheric carbon dioxide concentrations has occurred because of human activity since the industrial revolution, because of the widespread use of carbon-based fuels. Carbon dioxide is a substantial contributor to acidification of the oceans because it dissolves in water and produces carbonic acid. The earth's radiative balance is disturbed as a result of the rise in atmospheric concentrations of man- made greenhouse gases. As a result, the Earth's surface temperature is increasing, which has repercussions for global agriculture, climate change, and sea level rise. Carbon dioxide is the most significant contributor to global warming and climate change among greenhouse gas.

2.5 The Perception of Construction Industry on Carbon Dioxide Reduction in the Planning and Design Stage through Project Life Cycle

Agung Wibowo *et al*. (2018) said that the construction industry plays a significantly to worldwide carbon dioxide emissions. Carbon dioxide emissions are very well contributors to global warming and climate change, both of which can have catastrophic consequences for humans and the environment. CO2 emissions act as a layer in the atmosphere, generating frictional heat and warming the globe. (Ahmed Ali *et al*., 2020). In 2018, the buildings and construction industry accounted for 36% of final energy usage and 39% of energy and process-related carbon dioxide emissions, with 11% of those emissions coming from the manufacture of building materials and products such steel, cement, and glass (IEA, 2019). Meanwhile according to Klufallah *et al*. (2014) define construction projects are a significant source of pollution in the environment, and the construction industry's influence leaves unpleasant residues. The construction industry utilizes a tremendous number of natural resources and is one of the most polluting industries. The world is now struggling with global warming and climate change challenges. Carbon dioxide emissions are generated by energy released over the project life cycle of the building start to the end (Agung Wibowo *et al*., 2018). In a building, effective carbon reductions can be achieved by careful planning, design, and the use of energy-efficient materials. This is related to a decrease in operational carbon, which is the emissions brought on by a building's consumption of power and cooling during its lifetime (Kathy, 2021).

2.6 Carbon Dioxide Reduction Strategies through Planning and Design Stage in Project Life Cycle

According to S. Thomas Ng *et al*. (2012), building planning and design has a considerable influence on a project’s environmental impact. The World Green Building Council (2019) has released 40 percent reduction in embodied carbon emissions by 2030 and net zero emissions by 2050: this is a radical new ambition. The energy consumed to heat, cool, and light buildings accounts for 28% of total global carbon emissions from construction and building activities. During the life of a structure, emissions from materials and construction account for just 11% of total embedded carbon emissions. The WorldGBC's goal of totally decarbonizing the industry advocates for the removal of both operational and embodied carbon emissions.

(a) Green Building Design

According to World Green Building Council (2022), a "green" building is one that, by its design, construction, or operation, reduces or eliminates harmful environmental effects while potentially producing positive environmental benefits. Buildings that use less energy and resources are better for the environment and for human well-being. Any structure, even whether it's a house, a workplace, a school, a hospital, a community hall, or anything else, may be a green building if it has the criteria stated above.

Many research have advocated for a "green building" strategy to decrease Carbon footprints, and many studies have offered a "green building" way to reduce related emissions. Contractors, for example, may anticipate emissions created in following phases if they are aware of the ramifications of designs generated throughout the design process. Furthermore, by understanding the impact of each stage and the interaction between these phases throughout the project life cycle, designers may detect GHG emission potential and give ways to prevent high effects through the design of low carbon facilities (S. Thomas Ng *et al*., 2012). Architects should also pay attention to the notion of green building design, which may be used to solar energy, decrease waste, and improve the houses inside temperature. The use of scientific ventilation design may efficiently increase the circulation of interior air. The proper use of wind and solar energy may minimize the usage of HVAC systems to reduce the carbon dioxide emissions, eliminate wasteful waste, and increase public awareness of the use of green building concepts in architectural design (Zheng, 2021).

(b) Selection of green materials

Buildings employ a wide range of materials that consume energy and release CO2 over their life cycle, which is known as embodied energy and carbon. As part of mitigating methods, measuring the embodied carbon of building materials can help to reduce the carbon footprint. Sustainable building materials can reduce embodied CO2 emissions by 30% throughout the life of a structure. (Ahmed Ali *et al*., 2020). The use of building materials that are environmentally friendly may help to decrease the loss of natural resources during the construction of homes and achieve low- carbon environmental protection. A plethora of green materials have evolved as a result of the building industry's fast growth to provide a healthy living environment. Green, environmentally friendly construction materials may preserve tenants' lives and property by reducing the concentration of chemicals and other harms to the human body, as well as better regulating home humidity, temperature, safety, and other consequences. There will be several new materials as the building industry develops, so we must stick towards the notion of moving up with the times, paying attention to market developments, and ensuring the advanced nature of green design (Zheng, 2021).

(c) Use Low Carbon Technology to Design the Building Layout as Passive Methods

One of the technological solutions for lowering carbon dioxide emissions in buildings is low-carbon technology. Low-carbon technology is described as technology that emits the fewest greenhouse gases (GHGs), particularly CO2, into the environment. Low-carbon technology may also be used to create essential strategic demands of innovation-driven development in the building (Ahmed Ali *et al*., 2020). Mona N. Shah *et al*. (2017) said that building energy must be minimized by increasing the thermal efficiency of the envelope if significant reductions in building carbon emissions are to be achieved. The use of passive mode systems rather than active mode systems, together with architectural design and form, will result in a sustainable structure. According to Ahmed Ali *et al*. (2020), Renewable and sustainable energy technologies include evaporative cooling, passive ventilation, and cooling, solar photovoltaic, dehumidification, and energy recovery systems. These strategies have been found to help cut emissions and improve building energy efficiency. There are a variety of methods that may be utilized to heat a building while releasing little or no CO2, such as solar hot water, biomass heating, air source heat pumps, wind turbines and others.

According to Mona N. Shah (2017), Carbon emissions from buildings may be greatly decreased if the thermal performance of the building envelope is enhanced. The employment of passive mode systems rather than active mode systems, in conjunction with architectural design and shape, will result in a long-lasting building. Architectural design may adapt to reduced lighting equipment consumption by enhancing shape and design to make optimum use of natural light and ventilation. Lighting and architectural design must work together. Table 2.2 gives a few strategies that can be adopted to give a low carbon building design.

Table 2: Available strategies that can substantially reduce carbon dioxide emissions (Mona N. Shah, 2017)

Planning and Design Strategies	Building Envelope, Material and Equipment Selection	Added technology
Building shape, orientation and color	Adequate insulation values	Solar hot water heating
Spatial layout	Radiant barriers	Photovoltaic systems
Window shape	Low e-coatings and argon gas filled glazing	Micro wind electric generation

Day lighting	Thermal break windows and systems and movable insulation	Community scale solar, thermal, renewable energy systems
Natural ventilation	Sunlight and daylight fixtures and systems	Combined heat and power systems

3. Research Methodology

3.1 Research Design

The research design refers to the strategy to integrate the different components of the study in a fragmented way. It can figure out the mistakes and shortages of the researcher through the idea that has organized in a flow chart form (Akhtar, 2016). Firstly, obtain a rough idea of the research title that will be undertaken when the supervisor has been chosen. Following the organization of the idea, a research title is chosen, which is "Perception of construction industry players on carbon dioxide reduction through planning and design research designs stage in project life cycle". The research problem is then identified, and the objectives are presented based on the problem statement.

Next, the researcher does a literature review have a depth understanding with the research title. The information which is related with the research title can obtain from journal articles, reference books, research report and other sources of information. Data collection and data analysis methods are described. The method that would be used in this phase was content analysis purpose to ensure the data collected is matched with research objectives. Based on the findings, a discussion will be made. Finally, the research will come to a conclusion and recommendation will be provided as a conclude. The following is the flow chart of this research:

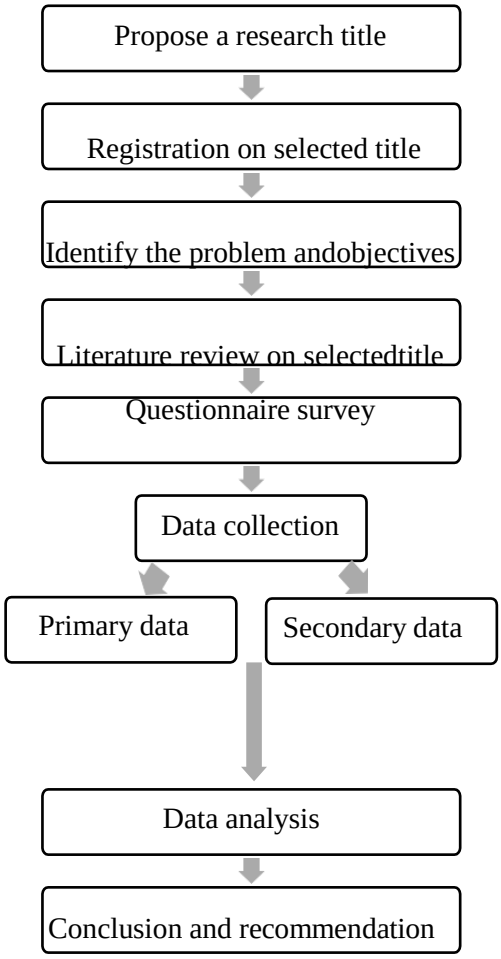

Figure 1: Research flow chart

3.2 Data Collection

This research consists two types of data, which are primary data and secondary data. All the information will be gathered through this primary data and secondary data. Thus, the method of data collection will be explored in depth. A questionnaire will be distributed to the target respondents gather the primary data for the study by using the quantitative method. The questionnaire will concentrate on the research objectives, which is to ensure that is achieved. The questionnaire was created by using Google Form and distributed by e-mail. The respondents involved in this research were in Johor Bahru, Malaysia. The researcher has distributed about 70 sets of the questionnaire form to each construction players with the total of 280 sets. The respondents will be random pick in the target respondents. Besides, data collected from sources that have been released in any form is called secondary data. The secondary data collection sources are references, journals, papers, articles and title-related publications. Analysis of data that collected from the questionnaire were 55 responses were completed the questionnaire form.

3.3 Data Analysis

In this research, the data received from the completed questionnaire will be analyzed using Statistical Package for Social Science (SPSS). SPSS is a software that makes it simpler for the

researcher to examine the large amount of data collected during the survey. to enter organized data from many sources, such as Excel, straight into the program. SPSS can analyze and generate or present the output in the form of tables or graphic such as pie chart or histogram. Next, the descriptive analysis is then used to characterize the findings' features using percentages, mean, and standard deviation. In order to assess the consistency of the statistics, reliability analysis is also used to examine the data collection. The presence of a high reliability value suggests that the findings are reliable, and that no revision is required.

4. Results and Discussion

4.1 Section A: Demographic information

Through the 55 questionnaires survey that returned from the target respondents, the age of respondent's majority are 21 to 25 years and consist 38.18%. The second highest group followed by 26 to 30 years and consist of 36.36%. In addition, 21.82% of respondents are above 31 years and only 3.64% of respondents are below 21 years. The questionnaire forms were distributed to targeted construction players in project life cycle include, architect, engineer, quantity surveyor, and project manager. Among the findings 55 (100%) obtained, there are 12 (21.82%) from architect, 10 (18.18%) from engineer, 8 (14.55%) from quantity surveyor, and 25 (45.45%) from project manager. These people play an important role and responsibilities in planning and design stage through project life cycle to reduce the carbon dioxide. Besides, the majority of respondents have a bachelor of degree (38.18%), followed by a Master (36.36%), and Philosophy of Degree (PhD) (21.82%). Only a minority of respondents have a diploma (3.64%) that participates in the survey. Based on this finding, this suggests that the respondents are fairly well educated and are eligible for this research. Almost 49.09% respondents have experience around 5 to 10 years, followed by 27.27% those 11 to 15 years, 20% respondents have experience above 16 years, and only 3.64% respondents less than 5 years' experience.

Table 3: Frequency and Percentage of respondents in demographic respondents

Demographic Respondent	Frequency	Percentage
Age		
Below 21	2	3.6
21 – 25	21	38.2
26 – 30	20	36.4
Above 30	12	21.8
Gender		
Male	38	69.1
Female	17	30.9
Ethnicity		
Malay	25	45.5
Chinese	27	49.1
Indian	3	5.5
Type of organization in construction industry		
Architect	13	23.6
Engineer	12	21.8
Quantity Surveyor	9	16.4
Project Manager	21	38.2

Highest academic achievement		
Diploma	2	3.6
Bachelor degree	21	38.2
Master Degree	20	36.4
PhD	12	21.8
Working experience in construction field		
Below 5 years	2	3.6
5 – 10 years	27	49.1
11 – 15 years	15	27.3
16 years and above	11	20.0

4.2 Section B: The perception of construction industry on carbon dioxide reduction through planning and design stage in project life cycle

Table 4: The perception of construction industry on carbon dioxide reduction through planning and design stage in project life cycle

The perception of construction industry on carbon dioxide reduction throughplanning and design stage in project life cycle.	Category	Mean	Ranking
The construction industry played a considerable role in rising carbon dioxide emissions.	Agree	4.04	4
Construction industry players did not properly handle the project life cycle, which brings in carbon dioxide emissions that indirectly contributes to global warming and climate change.	Agree	4.11	2
Carbon dioxide emissions are generated by energy released over the project life cycle of the building start to the end.	Neutral	3.65	11
Project life cycle refers to the sequence of activities that must be completed in order to complete the construction project, including initiation, project planning and design, execution, performance and monitoring, and closure.	Neutral	3.85	7
Carbon dioxide emission become more challenging due to construction's planning and design stage in project life cycle.	Agree	4.00	5
Planning stage are the project's purpose and scope, conduct feasibility studies, select land, or investigate site conditions, and the steps	Agree	4.04	4

necessary to achieve the project's objectives and goals are planned.			
Design is the communication of an idea or the resolution of requirements through tools like drawings, plans, specifications, and models.	Neutral	3.93	6
Do you consider that the roles and responsibilities of architect are important in carbon dioxide reduction through planning and design stage in project life cycle?	Agree	4.09	3
Do you consider that the roles and responsibilities of engineer are important in carbon dioxide reduction through planning and design stage in project life cycle?	Neutral	3.80	9
Do you consider that the roles and responsibilities of quantity surveyor (QS) are important in carbon dioxide reduction through planning and design stage in project life cycle?	Neutral	3.75	10
Do you consider that the roles and responsibilities of project manager are important in carbon dioxide reduction through planning and design stage in project life cycle?	Neutral	3.64	12
Carbon dioxide is the most major anthropogenic greenhouse gas, and worldwide increases in CO2 concentration are attributable to fossil fuel combustion and intensive land usage.	Neutral	3.75	10
The impacts of carbon dioxide emissions because of increasing global temperatures on natural systems and societies throughout the planet.	Neutral	3.75	10
Carbon dioxide boost global temperatures has an impact on water supply and weather patterns, as well as changing the growing season for food crops and putting coastal towns at risk sea levels.	Agree	4.31	1
Rising sea levels flood homes and roads, disrupting maritime operations, and have severe consequences on shorelines, particularly those heavily inhabited by people.	Neutral	3.82	8

Acid rain is caused by CO2, which harms tree and the built environment.	Agree	4.31	1
Weather pattern changes, geographical changes and change in food supplies also are the impacts of carbon dioxide emissions.	Agree	4.04	4

From the Table 4, we can observe that the mean value of 4.31 is presenting most of the respondents are agreed that carbon dioxide boost global temperatures has an impact on water supply, weather patterns, and acid rain. From Cairoli (2019) and Ahmed Ali *et al*. (2020), emissions of carbon dioxide are a contributing factor to global warming, which has the potential to have dire effects for both people and the natural world.

4.3 Section C: Carbon dioxide reduction strategies through planning and design stage in project life cycle.

Table 5: Carbon dioxide reduction strategies through planning and design stage in project life cycle.

Carbon dioxide reduction strategies through planning and design stage in project life cycle.	Category	Mean	Ranking
In a building, effective carbon reductions can be achieved by careful planning, design, and the use of energy-efficient materials.	Agree	4.29	1
Green building design help to protect the environment to mitigate climate change and enhance our quality of life.	Agree	4.29	1
The selection of green materials that are environmentally friendly may help to decrease the loss of natural resources during the construction of homes and achieve low-carbon environmental protection.	Agree	4.05	2
Low-carbon technology is defined as technology that emits the least amount of greenhouse gases (GHG) into the atmosphere, especially CO2.	Agree	4.05	2

Table 5 had clearly showed that the high mean value, 4.29 of the respondents agreed that use the energy-efficient materials and use green building design is positively to reduce carbon dioxide.

Table 6: Available strategies that can substantially reduce carbon dioxide

Available strategies that can substantially reduce carbon dioxide	Category	Mean	Ranking
Building shape, orientation and colour – Solar hot water heating	Yes	1.42	2
Spatial layout – Photovoltaic systems	Yes	1.40	3
Window shape – Micro wind and electric generation	Yes	1.49	1
Day lighting – Community scale solar, thermal, wind and biomass electric generation	Yes	1.24	5
Natural ventilation – Combined heat and power systems	Yes	1.25	4

Table 6 shows the ranking of strategies to reduce carbon dioxide through planning and design stage in project life cycle. Table 6 indicates that most of the respondents agreed the window shape is the strategies that can substantially reduce carbon dioxide with the mean value 1.49.

5. Conclusion

This section discussed the level of achievement of the researcher for each of the objectives of the study that have been made and assess whether or not the researcher's research accomplishes the objectives established. Based on previous section, data analysis and discussion, it is seen that the objectives of the research are achieved. The conclusion, limitation and recommendation were being summarized here. Based on the first objective of the research is to identify the perception of construction industry on carbon dioxide reduction through planning and design stage in project life cycle. The objective was achieved through questionnaire survey by sending email to the target respondents such as architect, engineer, quantity surveyor and project manager. The finding can clearly see that many impacts caused by carbon dioxide in construction industry such as climate change. In addition, the second objective of the research is to purpose carbon dioxide reduction strategies through planning and design stage in project life cycle. The objective also was achieved through questionnaire survey by sending the email to the target respondents. Majority of the respondents are in moderate level about the strategies to solve the problem about carbon dioxide emission through planning and design stage in project life cycle. The highest ranking of mean value in strategies to solve the problem are use of energy-efficient materials and use green building design.

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References

Agung Wibowo, M., Uda, S. A. K. A., & Zhabrinna. (2018). Reducing carbon emission in construction base on project life cycle (PLC). *MATEC Web of Conferences*, *195*,06002. https://doi.org/10.1051/matecconf/201819506002

Ahmed Ali, K., Ahmad, M. I., & Yusup, Y. (2020). Issues, Impacts, and Mitigations of Carbon Dioxide Emissions in the Building Sector. *Sustainability*, *12*(18), 7427. https://doi.org/10.3390/su12187427

Alicia,T. (2020). *Sampling Definition*. Investopedia. https://www.investopedia.com/terms/s/sampling.asp

Am Theron. (2018). *THE ROLE PLAYERS IN THE CONSTRUCTION PROFESSION AND THEIR RESPONSIBILITIES – AM Theron*. https://amtheron.co.za/the-role-players-in-the-construction-profession-and-their-responsibilities/

Akhtar, Dr. Md. Inaam. (2016). Research Design. *Available at SSRN 2862445*.

Cairoli, S. (2019). *Consequences of Carbon Emissions for Humans*. Sciencing. https://sciencing.com/consequences-of-carbon-emissions-for-humans-12730960.html

Competitive Advantage. (2021). *Construction Project Team Roles and Responsibilities*. Construction Sales & Marketing Knowledge. https://cadvantage-knowledge.co.uk/product/news-articles/articles/construction-project-team-roles-and-responsibilities/

Egeland, B. (2020). *The 6 Phases of a Construction Project Life Cycle*. PM Tips. https://pmtips.net/article/the-6-phases-of-a-construction-project-life-cycle

Eurostat Statistics Explained. *Glossary:Carbon dioxide emissions - Statistics Explained*. (2017). https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Carbon_dioxide_emissions

IEA. (2019). Global Status Report for Buildings and Construction 2019, IEA, Parishttps://www.iea.org/reports/global-status-report-for-buildings-and-construction-2019

Indeed Career Guide. (2021). *A Guide to the Construction Project Life Cycle*. https://www.indeed.com/career-advice/career-development/construction-project-life-cycle#:%7E:text=The%20construction%20project%20life%20cycle%20refers%20to%20the%20order%20of,final%20details%20of%20project%20completion.

Kathy. (2021). *How Green Buildings Reduce Carbon Dioxide*. Sustainable Investment Group. https://sigearth.com/how-green-buildings-reduce-carbon-dioxide/#:%7E:text=The%20advantage%20of%20a%20green,a%20net%20positive%20on%20the

Klufallah, M. M. A., Nuruddin, M. F., Khamidi, M. F., & Jamaludin, N. (2014). Assessment of Carbon Emission Reduction for Buildings Projects in Malaysia-A Comparative Analysis. *E3S Web of Conferences*, *3*, 01016. https://doi.org/10.1051/e3sconf/20140301016

Lu, K., Jiang, X., Tam, V. W. Y., Li, M., Wang, H., Xia, B., & Chen, Q. (2019). Development of a Carbon Emissions Analysis Framework Using Building Information Modeling and Life Cycle Assessment for the Construction of Hospital Projects. *Sustainability*, *11*(22), 6274. https://doi.org/10.3390/su11226274

Mona N. Shah & Bendigiri, Priyanka. (2017). *Layout planning and building design for low carbon buildings – A review literature.* https://www.researchgate.net/publication/323472120_Layout_planning_and_building_design_for_low_carbon_buildings_-_A_review_of_literature

Mushtaq, R. (2014). *The Management of Construction A Project Lifecycle Approach Malestrom*. ACADEMIA. https://www.academia.edu/9820952/The_Management_of_Construction_A_Project_Lifecycle_Approach_Malestrom

New report: the building and construction sector can reach net zero carbon emissions by 2050. (2022). World Green Building Council. from https://www.worldgbc.org/news-media/WorldGBC-embodied-carbon-report-published

S. Thomas Ng, Wong, J. M. W., Skitmore, S., & Veronika, A. (2012). Carbon dioxide reduction in the building life cycle: a critical review. *Proceedings of the Institution of Civil Engineers - Engineering Sustainability*, *165*(4), 281–292. https://doi.org/10.1680/ensu.11.00005

The World Bank. *Glossary | DataBank*. (2020). https://databank.worldbank.org/metadataglossary/world-development-indicators/series/EN.ATM.CO2E.PC#:%7E:text=CO2%20emissions%20(metric%20tons%20per,Source

Trinh, T & Doh, Jeung Hwan & Hou, Lei. (2017). An Overview of Building Lifecycle Embodied Carbon Emissions Research. From https://www.researchgate.net/publication/322797480_An_Overview_of_Building_Lifecycle_Embodied_Carbon_Emissions_Research

Tobias, M. (2021). *Roles and Responsibilities of Architects in Construction Projects*. Nearby Engineers. https://www.ny-engineers.com/blog/architects-in-construction-projects

World Green Building Council. (2019). *What is green building?* Retrieved May 20, 2022, from https://www.worldgbc.org/what-green-building#:%7E:text=A%20'green'%20building%20is%20a,improve%20our%20quality%20of%20life.

Zheng, L. (2021). Research on the Application of Green Building in Building Design. *IOP Conference Series: Earth and Environmental Science*, *783*(1), 012160. https://doi.org/10.1088/1755-1315/783/1/012160