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SCHOOL BUILDING UTILIZATION ANALYSIS NET ZERO CARBON IN JAKARTA ELEMENTARY AND HIGH SCHOOL

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ABSTRACT

This research aims to analyze the utilization of Net Zero Carbon school buildings in primary and secondary schools in Jakarta and its implications on students' green behavior and the involvement of various stakeholders in supporting the net zero school program in efforts to reduce emissions in the city of Jakarta. This study employs qualitative methods, gathering data through questionnaires, interviews, and document studies. The findings indicate that, besides producing a low Energy Consumption Index or being energy efficient, Net Zero Carbon schools also have a positive impact on increasing students' awareness and sustainable behaviors. Stakeholder engagement is found to be crucial in supporting the implementation and success of this initiative. These findings provide insights for further development in sustainable building in the education sector.

Keywords: *net zero carbon school buildings, ike, green behavior, educational sustainability, school management, jakarta*

INTRODUCTION

The energy sector is the largest contributor to greenhouse gas emissions globally (Ministry of Energy and Mineral Resources, 2020), and most of the environmental damage is attributable to the architecture and construction industry, namely the design, construction process and operation of buildings. It is a fact that building energy use is currently responsible for 39% of all global carbon dioxide emissions. Carbon from building construction, called "contained carbon," adds 11% to CO2 emissions. In addition, the spread of toxins, ecological damage, water pollution, evictions, and destruction of bio-habitats can all point to the architectural and operational sectors of buildings (The American Institute of Architects).

According to the World Green Building Council (2020), buildings and construction together are responsible for 36% of global energy consumption and nearly 40% of global carbon emissions. The construction sector, including buildings, accounts for 24.6% of greenhouse gas emissions. Meanwhile, according to the Green Building Council Indonesia (GBCI), the building uses 36% of the energy produced. Buildings are responsible for over 39% of carbon emissions and the biggest climate change drive globally. In response to these conditions, many building constructions have used Building Information Modeling (BIM) technology and the application of green buildings in order to help reduce the carbon footprint of buildings and reduce the amount of energy consumed by buildings.

Jakarta as the center of Indonesia's economy and a global city, has a crucial role in implementing and promoting green building in Indonesia. According to data from the Central Bureau of Statistics DKI Jakarta, the number of IMBs issued in Jakarta in 2019 was 10,763, in 2020 it was 6,798, and in 2021 it was 10,131. These numbers represent the number of buildings that have obtained an IMB, and there may be buildings that have not obtained an IMB. This is a reflection that Jakarta can be a barometer in the application of green buildings in infrastructure and educational innovation, including in Net Zero Carbon schools.

Realizing this, the DKI Jakarta Provincial Government seeks to improve green building practices and the steps that have been taken in supporting green buildings, one of which is the issuance of Jakarta Regional Regulation Number 38 of 2012 concerning Green Buildings. This regulation regulates the planning, construction, utilization, maintenance, and demolition of buildings in Jakarta. The focus is on energy efficiency, water efficiency, indoor air quality, sewage and soil treatment, and construction activities. This regulation is a reference for the community to realize development that considers aspects of conservation and efficient use of resources.

Pemerintah Provinsi DKI Jakarta melalui Dinas Pendidikan pada tahun 2022 telah built a Net Zero Carbon Building that makes it a green school at SMAN 96 Jakarta, SDN Ragunan 08, SDN Duren Sawit 14 and SDN Grogol Selatan 09. The construction of Net Zero Carbon school buildings in the four schools is very important because it is not only an effort to achieve carbon emission targets, but protect the environment, keep teachers and students healthy, and promote environmental literacy. Building a green school means preparing the next generation of environmental leaders (Earth day).

Green schools have the potential to influence student behavior outside the school environment. The World Green Building Council (WGBC) believes that school children spend more time in educational buildings than anywhere else than their homes so green schools have a measurable impact on their well-being and development as they leave school.

Green-Schools were also found to have a positive impact on responsible consumption behavior, not only in the latest generation of consumers or children but also in the current generation of adults through the power of positive persuasion (O'Neill &; Buckley, 2019). Green-schools programs encourage sustainable consumption practices by instilling environmental values and behaviors in students, which then influence their families and communities to adopt more sustainable practices (O'Neill & Buckley, 2019).

The physical environment, education and awareness have an important role to play in promoting sustainable behaviour in schools. Green education initiatives, such as eco-friendly school projects, help raise awareness and provide opportunities for students to study environmental issues (Maurer et al., 2020). By integrating environmental knowledge and values into the curriculum, schools can empower students to make informed decisions and take action to protect the environment (Maurer et al., 2020).

In line with previous research, individual awareness and knowledge of sustainability and green practices have been found to have a positive influence on pro-environmental behavior (Ibnou-Laaroussi et al., 2020). The study shows that there is a positive relationship between individuals' perceptions of the sustainability of green tourism and their attitudes towards participation in environmentally responsible behaviors (Ibnou-Laaroussi et al., 2020).

In another study, it was found that there was no significant increase in green building knowledge over time for students in eco-friendly schools. Although eco-friendly buildings can increase students' knowledge of sustainability. Such determining factors such as school practices play an important role in influencing environmentally responsible student behavior (Teichmann et al., 2023). It becomes important to involve students from planning, managing, and maintaining green spaces in schools to have a positive impact on their attitudes towards greening and their involvement in the management and maintenance of school green spaces (Teichmann et al., 2023).

Based on these phenomena, the author is interested in examining how after the use of Net Zero Carbon schools that have been built by the DKI Jakarta Provincial Education Office with their relevance in terms of supporting sustainability and achieving emission reduction targets in DKI Jakarta. Based on the formulation of the problems presented, the objectives in this study include: To analyze and examine the use of Net Zero Carbon schools in elementary and high schools in DKI Jakarta. To analyze and examine the relationship between the use of Net Zero Carbon schools and green behavior of students. To analyze and assess the involvement of various stakeholders in influencing the successful implementation of Net Zero Carbon school development goals.

METHOD

This research was conducted with a qualitative descriptive approach to understand and interpret social phenomena from the perspective of research subjects, namely the use of net zero carbon buildings in elementary and high schools in DKI Jakarta by residents and stakeholders and how the use of net zero carbon buildings relates to the green behavior of students.

This research was analyzed using content analysis of primary data obtained from questionnaires and in-depth interviews distributed to respondents. The study respondents were selected using purposive sampling techniques. Purposive sampling is commonly used in qualitative research. Secondary data will be obtained from internal school documents, the DKI Jakarta provincial Education Office, and other publications related to the object of research.

The research will be conducted in several elementary schools and high schools in DKI Jakarta that have implemented the concept of net zero carbon buildings, namely at SDN Ragunan 08, SDN Duren Sawit 14 and SDN Grogol Selatan 09, then at SMAN 96 Jakarta. The four schools are a pilot project from the DKI Jakarta Provincial Education Office in building green schools. The inauguration of the net zero carbon schools was carried out on September 28, 2022, which means that if calculated to date, the net zero carbon building has been used for one year by students, teachers and the school community. The selection of research sites consisting of elementary and high school levels aims to obtain variations in data and experiences from different research subjects. The research time will be from October to December 2023.

The population in this study includes three elementary schools and one high school in DKI Jakarta that use the concept of net zero carbon. While the research subjects are teachers, students, and parents of students and other related parties. The source of data obtained in this study was taken from primary data and secondary data.

RESULTS AND DISCUSSION

Research findings related to green behavior

Student Perspectives

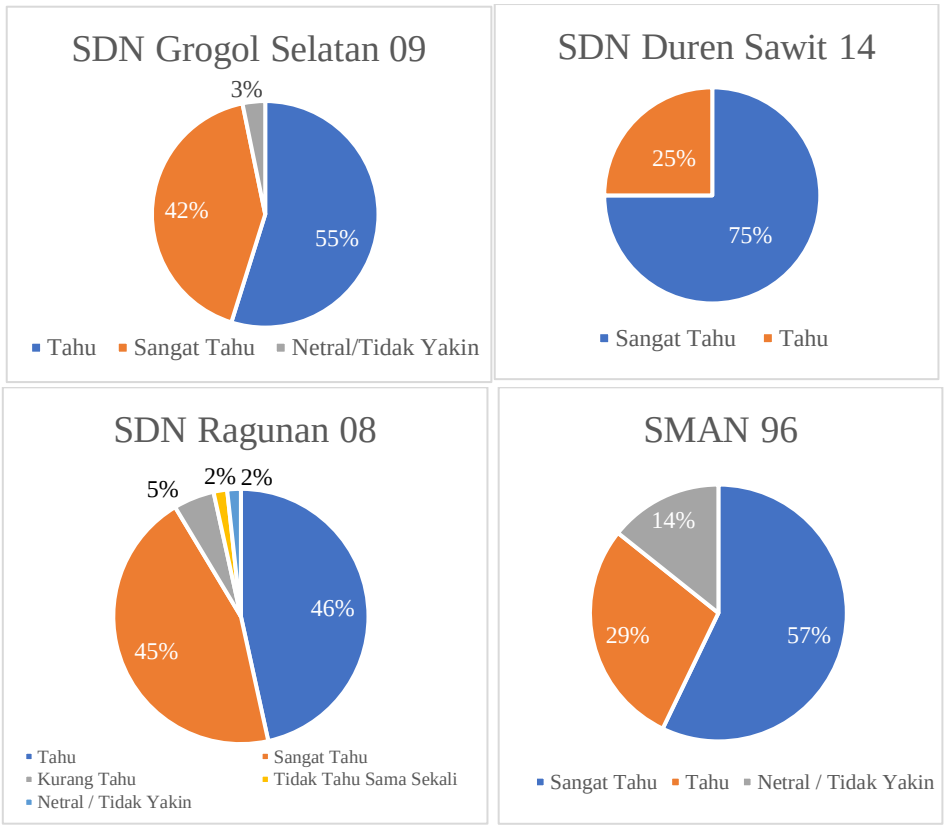

Figure 1. Students' Awareness and Knowledge of Net Zero Carbon Buildings in Their Schools

Source: Data processed

Figure 1 shows that most respondents know that the school building they are using is a Net Zero Carbon school building and understand the meaning and significance of Net Zero Carbon schools. From the results of in-depth interviews, students influenced from Net Zero Carbon schools are occupied with more positive behavior changes, namely increasing motivation in learning, time discipline, fostering new habits in protecting the environment and increasing relationships from changing conventional school buildings to Net Zero Carbon school buildings.

Figure 2. Student perspectives on the impact of Net Zero Carbon Schools on student behavior change

Source: Data processed

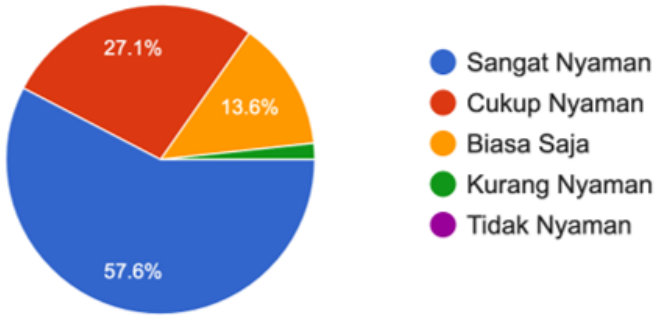

Figure 3. Student Comfort Level towards Net Zero Carbon Schools
Source: Data processed

Summary of the benefits obtained by students from interviews with students with school buildings to be net zero carbon

Table 1. The Effect of Net Zero Carbon Schools on Student Behavior Change

No.	Aspects	Impact on Students
1	Comfort	– Feel more comfortable in learning both in terms of better lighting, cleaner air, cleaner environment, better facilities (modern) and learning and play spaces become wider and varied. – Have new and outdoor learning spaces; study on the *rooftop;* – Become more focused on learning.
2	Personal Development	– Improve in time discipline. – Increase sense of responsibility. – Raising environmental awareness. – Increase social interaction with peers, underclassmen, seniors and teachers. – Increase creativity. – Increase new knowledge about the environment
3	Culture / Lifestyle	– Growing a lifestyle of protecting the environment such as not littering, watering plants in the environment, reducing the use of air conditioning, reducing the use of plastic, saving water, not excessive use of goods, – Bringing your own supplies – Study more orderly.

The culture of protecting the environment by students, especially at SMAN 96 Jakarta, is encouraged by programs implemented by the school, such as reducing the use of Bottled Drinking Water (AMDK) with campaigns using tumblers and refilling drinking water. In the school cafeteria, there is also a policy of not being allowed to sell AMDK.

Figure 4. Poster Urging Carrying a Tumbler at SMAN 96 Jakarta
Source: Personal Documentation

Teacher's Perspective

From the data collected, teachers in net zero carbon schools show a very positive response to buildings that have adopted net zero principles.

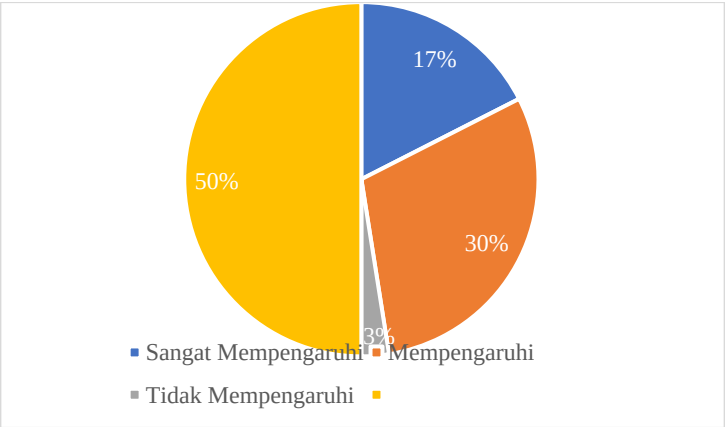

Figure 5. Percentage of Teachers' Confidence in Schools Net Zero Carbon Benefits the Quality of Education in Schools
Source: Data processed

Teachers recognise that a cleaner, healthier learning environment has a direct impact on their well-being and productivity. Teachers state that building design that prioritizes natural ventilation and lighting has created a more comfortable learning atmosphere, which they consider an important factor in supporting an effective educational process.

Further observations and interviews revealed that the existence of net zero buildings contributes to an increase in green behavior among students and teachers. Habits such as turning off lights and air conditioning when not needed are becoming more common, indicating increased awareness about the importance of energy conservation. In addition, some teachers are also involved in school initiatives, such as recycling programs, which show increased active involvement in school sustainability practices.

Net zero building not only serves as a place of learning, but also as a medium of education and sustainable behavior transformation. Teachers use every area in the school environment as a fun learning place, moving classes make teaching and learning activities not boring, students are happier, and comfortable at school. This underscores the importance of considering human and behavioral aspects in sustainable building design and management.

In addition to the positive impact, teachers view that in order to optimize the use of net zero buildings, socialization is needed to all building users, both students, teachers, guards, and all elements that are in direct contact, related to governance and the use of several tools that have never been used in schools before. For example, socialization of dry toilets, socialization of not snacking or bringing provisions that produce garbage, socialization about opening and closing windows so that air circulation remains good, and others and all parties are ready to occupy the new building. In addition, it is expected that supervision in the construction process will be even stricter, so that the building is maximized because there has been some damage. Another hope is increased safety safeguards and natural vegetation around openings to lower microtemperatures and reduce noise.

Parents' Perspectives

Dari data yang dikumpulkan melalui kuesioner dan wawancara, hampir keseluruhan orang tua mengamati peningkatan kesadaran lingkungan dalam keluarga sejak anak-anak mereka mulai belajar di sekolah dengan gedung net zero. Perubahan perilaku spesifik terkait keberlanjutan, seperti penghematan energi dan pemilahan sampah, menjadi lebih terlihat di rumah. Orang tua menyatakan bahwa gedung net zero tidak hanya memberikan dampak positif terhadap perilaku dan kesehatan anak-anak mereka, tetapi juga mempengaruhi anggota keluarga lain dan teman sebaya anak-anak, menciptakan efek domino dalam adopsi perilaku hijau.

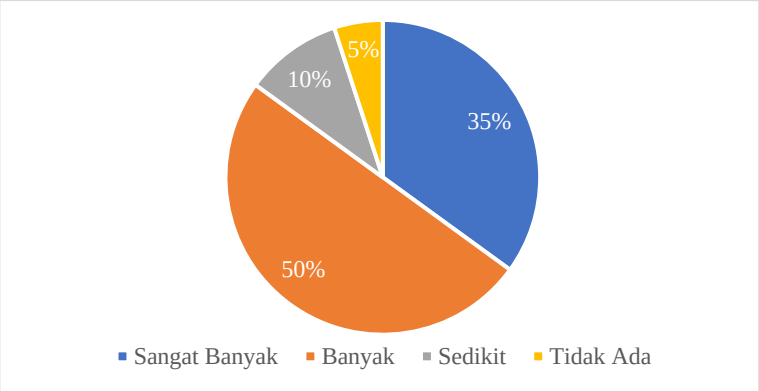

Figure 5. Parents' Views the Impact of Net Zero Building on Changes in Children's Behavior Related to Sustainable Behavior at Home (Example: Energy Saving, Waste Segregation)
Source: Data processed

In line with the concept of net zero implemented in schools, some parents feel inspired to adopt similar practices in their homes or workplaces. Knowledge of the concept of net zero is often sourced from information obtained from schools, underscoring the importance of effective communication on the part of schools in spreading these initiatives.

Parents also noted that education spending was reduced due to the cost efficiencies associated with net zero facilities. They acknowledge the positive impact on children's enthusiasm for learning and their behaviour, along with improved school communication on net zero initiatives.

Based on the feedback, parents felt there was room for schools to further increase the positive impact of the net zero concept, such as through participatory activities that involve more students and families. Finally, some parents expressed a desire to be more deeply involved in the school's sustainability efforts, signaling a communal commitment to a sustainable environment.

This shows that net zero schools not only serve as places of formal education but also as community centers that promote sustainable lifestyles.

Regulator's Perspective

The DKI Jakarta Regional Government Education Office, through its representatives in the education infrastructure unit, said that the DKI Jakarta Regional Government Education Office has shown commitment to the importance of developing net zero schools as part of sustainable development programs. With a significant budget allocation of Rp 406 billion, Dinas Pendidikan invests in creating a learning environment that supports health and thermal comfort, while contributing to the reduction of carbon emissions.

In terms of determining the location of the construction of Net Zero school buildings, several priority aspects are considered, namely: The level of damage to the building, the age of the building, the adequacy of the carrying capacity, flood conditions, Leadership policies

Funding for the construction of net zero carbon school buildings is directed at ensuring that aspects such as cross ventilation, stack effects, open space, the use of solar panels, and green landscapes are priorities in net zero carbon school design. The Education Office emphasized that there is no difference in budget allocation between elementary and high schools, but adjusted the building space program to the needs of each level of education. For now, there are no special schemes or incentives for schools that successfully implement and utilize net zero facilities optimally.

An explanation from the Education Office that from the perspective of schools that have received funding, there are reports of significant operational cost savings, especially in reducing monthly electricity costs. This shows that investment in net zero buildings has a direct impact on school budget management. In addition, the installation of solar panels has become a valuable learning medium and increased environmental awareness among students.

The positive response from the schools reflects that the net zero carbon approach yields not only financial but also pedagogical benefits. This allows students to learn and apply eco-friendly concepts directly at school, which they then take home to their families and neighborhoods.

In the next five years, the Education Office hopes to increase the quantity and quality of net zero carbon schools, both for new and existing buildings. This is expected to help achieve the carbon emission reduction target set by the DKI Jakarta Provincial Government. Net zero School Buildings are energy-efficient buildings that can reduce carbon emissions and meet the requirements of thermal comfort and indoor air health, considering that the World Green Building Council has launched the Advancing Net Zero program where all new buildings will

adapt the net zero concept by 2030 and all buildings will become net zero buildings by 2050. The construction of net zero school buildings is expected to support the efforts of the DKI Jakarta Provincial Government to achieve the target of reducing emissions in 2030 by 30% and an ambitious target in 2050 of 50% where the DKI Jakarta Provincial Government has passed Governor Regulation No. 90/2021 concerning the Low Carbon Development Plan for Climate Resilient Areas which is a climate action plan to achieve commitments in contributing to the Enhanced NDC.

Perspektif Green Building Council Indonesia

According to GBCI Advisor, for green building design, the design must from the beginning have embraced green principles, namely applying natural ventilation and natural lighting. To achieve this, a guideline is needed in Indonesia because there is no one for the construction of schools and universities. One of the important things is the local wisdom of the building and the basic philosophy of green building. The basic philosophy of green building is resource conservation, resource efficiency, and sharing of natural resources. The philosophy is mainly to maintain the balance of nature.

Based on existing data, 90% of humans currently live and productivity in buildings, therefore green building is the key to the sustainability of human health and well-being. Sourced from WGBC, research proves that rooms with good air quality, acoustics, lighting, and optimal levels of thermal comfort, can produce better cognitive performance, improve sleep quality, and a number of other tangible benefits for humans, including in this case implementing green buildings in schools or green schools.

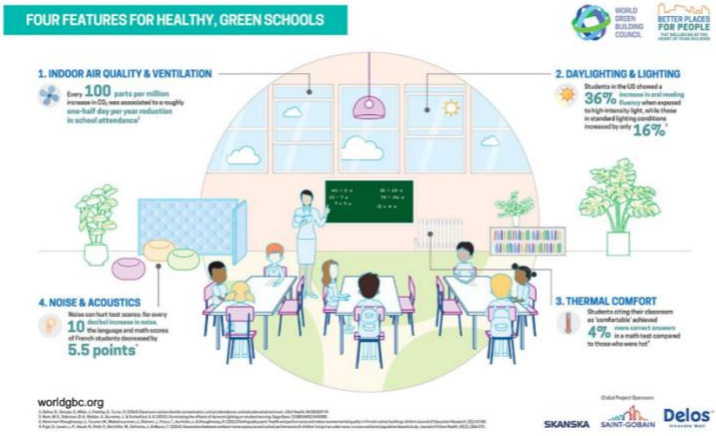

Figure 6. Key Indicators for Healthy Green Schools
Sumber: GBCI, 2021

Climatic conditions have a significant influence on the design of buildings including schools. Indonesia as part of the tropics, has a hot and humid climate character. DKI Jakarta gets sunlight throughout the year. The character of the minimum air temperature in the range of 20-23 oC and the maximum air temperature range in 27-32 oC with relative humidity in a fairly high range of 75-85%. In terms of schools in Jakarta, multi-storey school buildings have the potential to take advantage of stack-effects in corridors and void areas. Naturally can be utilized natural ventilation of air, while artificially can be assisted with mechanical equipment that can encourage savings in electrical energy consumption. Net zero school buildings in

Jakarta need to be evaluated regularly for review and improvement of the condition of the net zero buildings. One evaluation is to apply for net zero certification.

Stakeholder Analysis

The use of Net Zero Carbon schools in Jakarta in addition to having a dependence on technical aspects and sustainable infrastructure, as well as on the involvement and support of various stakeholders. In this study, identified stakeholders include students, teachers, education personnel, parents, education offices, and non-governmental institutions, which play their respective roles in the net zero carbon education ecosystem.

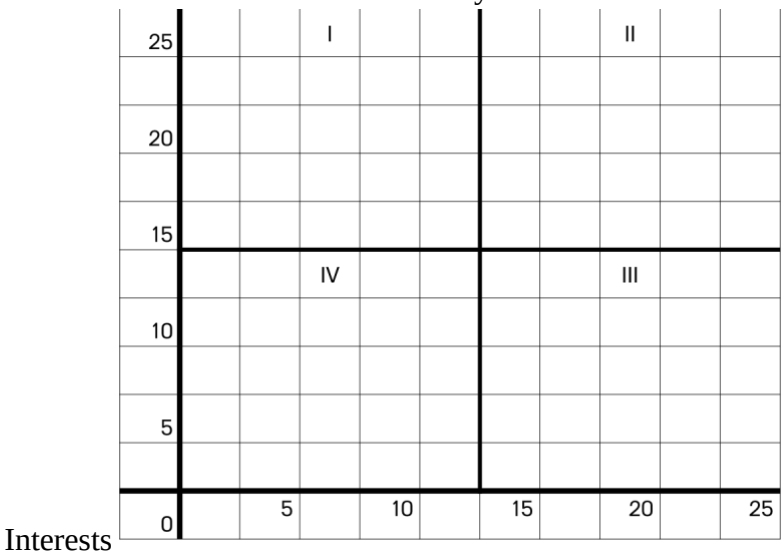

Figure 7. Importance-influence matrix
Image source: Reed et al. 2009

Information:
Quadrant I : Subjec/ Subject (Low influence, High importance)
Quadrant II : Player (High influence, high importance)
Quadrant III : Actor (High influence, low importance)
Quadrant IV: Spectator (Low influence, Low importance)

Quadrant I (subject) indicates a group of stakeholders who have a high importance to the activity but low influence, including individuals who carry out the activity and are responsive to the implementation of the activity but are not policy makers. Quadrant B (players) is a group of stakeholders who have a high degree of influence and importance to succeed the activity. Quadrant III (actors) are influential but low-importance stakeholders in achieving goals and high wisdom results. Quadrant IV (spectators) represents a group of stakeholders who are low in influence and importance. Its influence does not change the circumstances and its importance is not affected.

The analysis shows that stakeholders have different levels of importance and influence in the use of net zero carbon schools:

1. Students and Teachers (Subject) are direct users of facilities and key beneficiaries of a healthier and more conducive learning environment. Their role is important as advocates of

green behaviour and sustainability at school and at home. They are heavily affected by green building, but their influence on policy and implementation is low.

2. Dinas Pendidikan/Local Government and Green Building Council Indonesia (Player), Responsible for strategic decisions and resource allocation, in planning and implementing net zero carbon principles, as well as integrating them into school curriculum and operations and creating policy guidelines for green building development.
3. National Government and Private Sector (Actors): Through regulations, policies, and support programs, public and private (non-governmental) have an important role to play in providing financial assistance, and encouraging sustainability practices in education.
4. Parents: They have a vested interest in the quality of education and the environment in which their children learn, although their direct influence on school policy may be limited.

CONCLUSION

Based on the results of research that has been conducted to analyze and examine the use of net zero carbon school buildings in elementary and high schools in Jakarta in supporting the achievement of sustainability of the city of Jakarta, the following conclusions can be drawn: Net Zero Carbon School Utilization: 1.) Most elementary and high school buildings in Jakarta have lower IKE values than recommended, there are even lower than those who have used the Net Zero building. Schools that adopt net zero carbon principles have significant potential to reduce energy consumption and good air circulation. Challenges in aspects of maintenance and operational costs demand the development of a more mature and structured strategy to maximize the potential of sustainable buildings. The COVID-19 pandemic has sharpened the focus on health standards in the school environment. Net zero carbon schools with improved ventilation systems offer solutions to health challenges. Net Zero Carbon schools can serve as an environment that supports the health of students and teachers. Learning environments designed around sustainability principles have served not only as places of formal education but also as laboratories. Facilities that support learning concepts such as "moving classes", by utilizing open spaces in the building environment such as hallways, parks, other open spaces and the use of rooftops installed solar panels into the transformation of the learning system. 2.) The Effect of Net Zero Carbon Schools on student behavior: Net Zero Carbon Schools with the process of infrastructure revitalization, modernization, improving the aesthetics and functionality of environmentally friendly buildings, become intervention factors and stimuli for students in instilling green awareness, green behavior, and green satisfaction in daily life not only applies at school but also outside school. Nonetheless, this research indicates that to maintain and develop sustainable green behaviors, continuous and integrated educational initiatives are needed into school curricula and activities. The positive response from stakeholders is an indication of acceptance of the net zero carbon concept. However, this study also identifies the need for improved communication strategies to address understanding gaps and to increase stakeholder involvement in the management and operation of Net Zero Carbon schools effectively. Policy support is the foundation for school development planning, both public and private, to switch to a net zero carbon model. However, the policy needs to be followed by adequate incentives and funding for wider implementation.

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