A Green Infrastructure Strategy for Energy Efficiency in Urban Context

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Abstract. In the process of urban development, the more intensive areas are intensive, causing problems of urban congestion, traffic congestion and parking space, and they are the main source of energy consumption. Urban development guided by the development of the mass transit system is widely discussed. However, the problem of improving urban development is not only the construction of the mass transit system, but also the planning of the human environment system, as well as green infrastructure and green transportation. Through literature analysis and field investigation, this study hopes to create a friendly urban environment through the experimental design of roads, buildings and streets around the five power stations (Lilin, Toujiacuo, Songzhu, Jingwu and Wuquan) to truly reduce energy use.

1. Introduction
Taiwan is an urban development environment with dense population and convenient transportation. Nearly 50% of traffic actors use private transportation via the main means of vehicles and scooters. However, these vehicles not only cause carbon emissions that are the main source of pollution in the cities, they also cause urban traffic congestion, parking lot problems, noise pollution, and otherwise decrease the quality of urban living environment. Improving the urban traffic environment is related to the sustainable development of the city as a whole. In recent years, the urban planning concept of mass transit-oriented development has begun to be valued by all countries. The convenience of mass transportation and its overall development have provided opportunities for redevelopment of the surrounding areas of the train station. Taichung Station has added new train stops in response to the railway elevated MRT to increase the mass transit usage rate in Taichung City. However, the construction of the mass transit system consists of not only the mass transit, but also its serial connection with the surrounding green traffic transport system. This is often neglected, resulting in an inability to increase the utilization rate.

At present, the research on mass transit-oriented development and green infrastructure is concentrated on formulating development strategies around the station, such as Tsai (2004)[1], Shiao (2003)[2], Chen (2017)[3], Wen (2012)[4], Hsieh (2008)[5], Wu (2013)[6], Lin, (2010)[7], Hsu et al. (2019)[8], emphasis on experimental design, however, is relatively lacking. Through practical operations, academic one hopes to emphasize the importance and functionality of green infrastructure construction, improve the energy efficiency of urban environments, and reduce the use of urban energy. In this study, 500 meters of the surrounding area of Wuquan Station in Taichung City was selected as the design experiment object, and the original human traffic environment system was rethought and designed to provide a more suitable human environment space.

2. Literature review
2.1. Definition of green infrastructure
For Mark A. Benedict, and Edward T. McMahon (2001) [9] green infrastructure is any nation’s natural life support system — an interconnected network of waterways, wetlands, woodlands, wildlife habitats, and other natural areas; greenways, parks and other conservation lands; working farms, ranches and forests; and wilderness and other open spaces that support native species, maintain natural ecological processes, sustain air and water resources and contribute to the health and quality of life for communities and people. According to Jane Heaton Associates (2005) [10] green Infrastructure is a network of multi-functional green space that contributes to the high quality natural and built environment required for existing and new sustainable communities in the future. It consists of both public and private assets, with and without public access, and in both urban and rural locations. Sustainable communities balance and integrate the social, economic and environmental components of the community. Cambridgeshire Horizons Endurance House (2006) [11] defines green infrastructure as the sub-regional network of protected sites, nature reserves, greenspaces and greenway linkages. Green infrastructure should provide (where possible) multi-functional uses, i.e., wildlife, recreational and cultural experience, as well as delivering ecological services, such as flood protection and microclimate control. It should also operate at all spatial scales from urban centre through to open countryside.

3. Research methods
The discussion of the energy efficiency of urban infrastructure due to green infrastructure involves a wide range of perspectives. This study uses the literature on mass transit-oriented development and green infrastructure to explore the relevant indicators of green infrastructure through its predecessors as a follow-up design strategy. Li (2015) [12], Feng (2015) [13], Yeh (2013) [14], Hsu and Chao (2019) [15], etc. all use the secondary data method as an indicator construction and argumentation. This study uses the secondary data method to collect, summarize and organize the essence of previous research, and then proposes the human-oriented traffic environment design through the experimental design of the green infrastructure strategy.

3.1. Research background and scope
The Wuquan Station is one of the five new stations added to the Taichung Railway's elevated MRT, with a relatively high number of people per day. However, it does not have a complete human-environment system. At present, the pedestrian system and the bicycle lane system do not constitute a comfortable, continuous and unobstructed environment. The nearest mass transit system from the station takes 10 minutes to walk. These reasons have led most people to arrive at the station by private transport, as shown in Figure 1.

Figure 1. Research scope

4. Results and discussion
4.1. Experimental Design of Taichung Wuquan Station Pedestrian System
The original road was a car-based road. Although this road is very wide, the width of the sidewalk is sharply reduced in this car-based condition, only 1.5 meters wide. This leads to the fact that the sidewalks and bicycle lanes are not separated from the lane, which is very dangerous and inconvenient. Therefore, this experimental design will change the original concept and transform the car-based concept into pedestrian-oriented concept. We reduced the original lanes from dual carriageway 6 to dual carriageway 4, and retracted the building by 15 meters to enlarge pedestrian space, and the pedestrian and the bike path are separated on this scale, ensuring the safety of people and vehicles. This large-scale walking space will provide sufficient conditions for green coverage to further change the urban ecological environment. This greening not only creates a comfortable walking space, but also introduces relevant activities to meet the local cultural needs and increases the interaction among neighbors. Although the size of the buildings have been retracted, the surrounding environment will bring huge appreciation space for the real estate, and bring great commercial value to the lower-level commercial shops, as shown in Table 1.

Table 1. Experimental design of road.

| The status of the road at Wuquan Station |
|-----------------------------------------|
| Road design of Wuquan Station          |

4.2. Experimental design of building pedestrian environment systems
Many of today's buildings are square boxes, and people can only walk around the building, thereby there is no creative relationship between people and buildings, so how do we adapt the building to the walking system? My design cut the original square box building and turned the original square box building into a building with a terrace corridor. The benefit of this change is that it not only brings more commercial value to the shops on the first floor along the streets, but also turns the top cover of the first floor into the city pergola, so the city is provided with a better ecological environment and the local activities that will be introduced on it, so that more dialogue can be made between the house and the surrounding area. The building is pushed and pulled out of the open space and separates the residential area from the tourists, not disturbing each other. Finally, this layered design activates the atmosphere of the entire neighborhood and promotes the use of the walking system. Nowadays, many cities are still in an unsafe state. When walking in the streets late at night, there will always be some
insecure feelings. However, this layered design has a monitoring effect on the road surface. Pedestrians have more security and people are more willing to use the walking system. At the corner of the street, it is usually a place where people flow, but most of the buildings today have no place for people to gather because of the straight walls. We cut and push the rectangular house. The design makes people flow here by this convo groove style, and people have more interactions and gatherings here. It is also the hope that pedestrians do not necessarily walk along the periphery of the house. In a people-oriented environment, the building should not be allowed to influence people through the moving line. It is expected that there will be space for people to walk inside the house. The formation of an open or semi-open space can create a better walking atmosphere in addition to a more complex space utilization. This design is based on the bold idea that if each intermediate tunnel is handed over to the owner of the building, then there will be competition between each commercial tunnel design. The more beautiful the commercial tunnel is, the more people walking around it will attract. Therefore, it will bring more commercial value to the building. Under such a competitive situation, it will bring the city more prosperity. As shown in Table 2:

Table 2. Experimental design of open space of buildings.

4.3. Experimental design of special space pedestrian environment system
In today's busy urban environment, people are mostly mechanically commuting to work, so we hope to add new vitality into the city through an interesting street environment that suits the surrounding atmosphere. In the visualization based on Wuquan Station, on the left side is a small primary school and on the right side of the figure is the art center. Then this road is used to connect the school with the art center. Art does not have to be exhibited only in museums, and art can be integrated into life, so this design proposes to integrate art into the streets and display art on the streets. With the development of modern technology, most people have become phubbers and immerse themselves in the virtual world, thus here have been many problems among youngsters in the different aspects of their development. Some studies have found that outdoor education can effectively improve these problems, so attention should be paid to it. Then, does there have to be a specific place for outdoor education? We believe that education should be in daily life. It is hoped that this green park can provide good space, such as street performances and street art exhibitions, so that people can find the beauty of life inadvertently and add new vitality into the city. This design can also bring more people to and enhance the commercial value of the shops neighboring the street.
Many of us think that public buildings must be isolated from surrounding environment with walls (such as courts). When people around these buildings feel constrained, this is not conducive to the future development of the city, so this project takes Wuquan station as the basis to re-conceive. (See Figure 1) In this base, the original court is a closed space, so people walking nearby will feel depressed and uncomfortable, and the opposite of it is the commercial street. In this case, it is decided to open the wall of the court, so that the block of the court, apart from the building itself, become a large green square, through which we can soften the serious atmosphere of the court. And two green streets are set up, making the court and the commercial street organically connected.

In the district of the court and the commercial street, there will be a huge demand for lunch and most people will choose to order meals. After that, where to eat is a problem. After a morning's work, people need to relax, so a planned mobile dining car place is set up on the commercial street, where people can go to buy and eat, and a large number of greenbelts are set up on the road to make people relax. A shared outdoor office park is set up on that commercial venue, so that the work can not only be limited to the cold office space but also in nature, and different functions are put into these buildings, to activate the walking environment.

Now in many cities, people in a certain area go out during working hours, so there will be fewer people. But fewer people in another area when they are off duty. People prefer to walk in a lively environment so it is hoped the use of complex buildings (the bottom floor is a commercial space and the middle is an office area, on the top floor of the high-rise is the garden) will make counter-urbanization a lesser possibility, creating more office opportunities, forming a mode of working at home, which makes people reduce the use of transportation as much as possible because they are closer to the places where they work. At the same time, this creates a more ecological environment for the city, so that there will be a busy business environment in the daytime, and promote people's hiking and shopping.

The traditional street only has the function of passing. With the development of the city, a street divides a block into two parts, and cars take away our original activity space, and we want to take back these rights, hoping to return the space that originally belongs to us as citizens. Green Garden Road is a unique urban landscape in Taichung city, which is equivalent to a green corridor. People can walk comfortably in the city through this green corridor, but some green garden roads lack diversified functions, and Wuquan station is just like this.

On the left front of the base is the library, on the right front is the residence, behind is the park and in the middle is the Green Garden Road, and below is the park. The buildings are arranged on both sides in a U-shape, so that the flow of people will gather here as a square. This block will be jointly developed to form an art and culture center, making the Green Garden Road in the middle as the link. First of all, the pavement will be changed from the original asphalt pavement to the floor tile pavement to take back the human-oriented sovereignty, so that people can freely cross the road and reduce the tension when passing a road. Then, the Green Garden Road can be turned into a green landscape road to attract people and create a better walking environment. Now, in the current state of societies, the frequency of face-to-face communication has decreased, so this also is a good space for people to communicate.

A high platform will be set up on the Green Garden Road, which can not only be the stage for performing and selling small commodities, but also can be a bleacher to watch the performances in the square and park above, and be used as a rest space for seats. Finally, the first floor of the building on the upper right will be turned into shops to further attract people and make up for the lack of commerce in this space. Through above methods, barriers can be broken down, further optimizing the area and creating better walking condition. As shown in Table 3:

Table 3. Experimental design of street.
5. Conclusion
Early urban development increased the density of urban development through the mass transit system and the diversified use of land. It is expected to improve the level of urban transportation services and reduce the use of vehicles and scooters to solve problems such as urban congestion and insufficient parking spaces. However, the introduction of the mass transit-oriented development system requires the cooperation of surrounding green transportation vehicles and green infrastructure. It includes facilities such as a sidewalk and bicycle lane network, a bicycle lane rental system and a bus transportation system, as well as a network of urban green belt systems and the blue belt systems. This
study takes the area of Taichung Wuquan Station as the research scope, reviews the current human-centered environment system, and proposes experimental design of pedestrian and bicycle systems, buildings and special environments. It is hoped that by improving the surrounding environment of the mass transit-oriented development system and the green infrastructure, there will be created a high-quality urban environment, living environment and leisure recreation space, and a considerable improvement in the utilization rate of the mass transit system to reduce energy use and improve energy efficiency.

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