GREEN RENOVATION FOR EXISTING BUILDINGS IN TAIWAN

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Abstract

This paper introduces the accomplishment of green renovation efforts for existing buildings in Taiwan. Existing buildings approximately account for 97% of total buildings in the country showing the great potential to become greener. Driven by the national green building policy, the Architecture and Building Research Institute (ABRI) of Taiwan subsidized 658 existing building renovation projects by 2008, including both public and private sectors The renovation projects were undertaken in four major aspects, ecology, energy saving, waste reduction, as well as health concerns, based on the concept of Taiwan's EEWH green building evaluation system. A variety of subtropical green building techniques were widely used in these projects, such as improvement of envelope heat insulation, upgrade of HVAC and lighting energy efficiency, adoption of biodiversity design, as well as enhancement of indoor environmental quality. These projects proved to be a demonstrative paradigm for existing building renovation in the construction industry.

Keywords

green building, building renovation, energy efficiency, biodiversity

1. INTRODUCTION

While the term "Green" has been a synonym of environmental protection worldwide, "Green Building" is also used to represent an environment-friendly and sustainable building in Taiwan. In general, the definition of the green building in Taiwan, based on EEWH evaluation system (standing for Ecology, Energy Saving, Waste Reduction, and Health), is a building with the characteristics of health and comfort that is capable of efficiently saving the consumption of energy and natural resources and reducing pollutions caused by wastes during its entire life cycle. The system was first announced in 1999 and comprised of seven evaluation categories, green, soil water content, energy saving, water conservation, CO_2 emission reduction, construction waste reduction, and sewer and garbage improvement. In 2003, the system was modified by further introducing two new indicators, Biodiversity and Indoor Environment Quality, and formed the current EEWH framework. Typically, the system can be applied to the overall environmental performance assessment during the design stage for all newly constructed buildings. However, existing buildings approximately account for 97% of total buildings in Taiwan (Figure 1) showing the great potential to be renewed green. Constrained by the existing conditions of these buildings, it would take more efforts and higher costs to become greener in achieving better environmental performance. Therefore, initiated from the prior “Green Building Promotion Program” implemented from 2001 to 2007 and followed by the current “Eco-City and Green Building Promotion Program” from 2008 to 2011, a series of green renovation projects played an important role in leading the industry to put more emphases on existing stocks. To date, seven major works have been undertaken with the completion of 658 projects, listed in Table 1, including green remodeling project for governmental buildings, green HVAC project for governmental buildings, building envelope heat insulation improvement project, indoor environmental quality improvement project, greening existing buildings for private sector, green diagnosis and renewal for existing governmental buildings, and building energy efficiency upgrade program. Among them, 358 projects were in the public sector and 300 in private. These projects and their outcomes are briefly summarized in the following section.

Figure 1 Existing Buildings possess a dominant percentage of total buildings that is more than 97%

Table 1 List of Recent Green Renovation Projects for Existing Buildings in Taiwan

Project Name	No. of Cases	Year
1. Green Remodeling Project for Governmental Buildings	99	2002-2007
2. Green HVAC Project for Governmental Buildings	97	2003-2007
3. Building Envelope and Roof Heat Insulation Improvement Project	336	2003-2007
4. Indoor Environmental Quality Diagnosis and Improvement Project	18	2004-2007
5. Greening Existing Building Demonstrative Project for Private Sector	56	2004-2011
6. Green Diagnosis and Renewal for Existing Governmental Buildings	14	2008-2011
7. Building Energy Efficiency Upgrade Program	38	2008-2011
Total	**658**	by the end of 2008

2. GREEN RENOVATION PROJECTS

2.1 Green Remodeling Project for Governmental Buildings

The green building remodeling work was one the major promoting items in the prior Green Building Promotion Program. By the end of 2007, 99 green remodeling projects have been undertaken for governmental buildings and public schools. The green remodeling projects mainly include a series of work based on Taiwan's EEWH green building concepts. Various green building remodeling techniques were adopted in the following aspects: (1) revitalization of ecological environment; (2) improvement of water infiltration and retention; (3) employment of building energy saving technologies; as well as (4) sustainable utilization of water resource.

(1) Revitalization of ecological environment

Figure 2 The constructed wetland in the National Cheng Kung University plays a demonstrative role in environmental education (Source: Jui-Ling Chen, 2005)

In Taiwan's Green Building Evaluation System, the "Biodiversity Indicator" and "Greenery Indicator" are both the most effective measures to reveal the quality of ecology. The purpose of these indicators is to create diverse green fields by providing proper soil, vegetation, hydrology, climate, and space. It also provides habitats for animals to hide, nest, forage, and breed. Via proper ecological revitalization techniques, the relationship between the original ecosystem in nature and the living environment of people can be restored in the building site. The indicators also encourage providing good aquatic environments through establishing ecological ponds, lakes, and riverbanks (as the constructed wetland in National Cheng Kung University successfully integrating with waste water treatment and rainwater utilization shown in Figure 2), creating various habitats for small creatures by means of providing porous environment and multi-layer greenery without human interference (as the ecological habitat in National Kaohsiung University shown in Figure 3), creating suitable habitats for creatures by protecting the soil and planting diversified species of native plants, butterfly-attracting and bird-attracting plants, etc.

Figure 3 Create an ecological habitat in National Kaohsiung University (Left: Use withered woods to create porous Environment to provide a place for animals to nest, forage, and breed; Right: Place floating logs, wooden stacks, tree roots in the pond for birds to perch (Source: ABRI, 2006)

(2) Improvement of water infiltration and retention

Figure 4 Permeable pavement in Tai-Tung Vocational School (Source: ABRI, 2006)

One of the EEWH ecological evaluation indicators, Soil Water Content, aims to mitigate the urban heat island effect, to enrich the soil, and to partly manage ground runoff, through better water infiltration and retention in the building site. Good water infiltration and retention can be achieved by the adoption of permeable pavements and the preservation of naked land. In the green remodeling projects, permeable pavements were widely used to increase the capability of water infiltration. Combining with the utilization of recycled and natural materials, such as bamboo tube wastes, into permeable pavement featured the remodeling project of Tai-Tung Vocational School as a distinctive case in improving permeability (Figure 4).

(3) Employment of building energy saving technologies

Building energy saving is the core concern of every green building assessment tools around the world. In the project, a variety of energy saving techniques, such as installation of outer sun-shading devices, utilization of renewable energy, and improvement of HVAC, water hating and lighting system efficiency, was adopted in not only achieving building energy efficiency but also representing subtropical building forms. In the remodeling project of National Taipei University of Technology, 64 solar cell sun-shading boards and 36 conventional shading boards were installed. These outer sun-shading devices incorporating photovoltaic panels not only produced renewable energy but also effectively reduced the heat load of façade (Figure 5). The indoor thermal environment was thus enhanced as well. The total estimated energy saving of the green remodeling project was about 6.15 million KWH, which was equivalent to 4 million kilogram reduction of CO_2 emission.

(4) Sustainable utilization of water resources

The average annually precipitation in Taiwan is approximately 2,510 mm, which is 3.5 times higher than the world average. Due to the high population density, however, the average precipitation per capita is only 4.4 m^3, which is less than one sixth of the world average. With the additional causes of uneven rainfall distribution, high water consumption, and low water utilization efficiency, water shortage can be viewed as one of the severe and urgent environmental issues in Taiwan. According to the domestic water consumption pattern, the water consumption amount of bath and toilet accounts for 50% of total consumption. Hence, in the green building project, general faucets and water closets of all cases were replaced with water saving fixtures. Besides, due to the geographical and topographical characteristics of Taiwan, more than 50% of rainfall flows into the sea without utilization every year. If the rainwater could be more effectively collected and used, the chances of drought might be decreased and ground runoff could be better managed. Chiang Kai Shek Memorial Hall is one of the demonstrative rainwater utilization cases. A 900-ton rainwater tank was installed that was able to provide 68-ton water for irrigation. The tab-water conservation is about 47% (Figure 6). For the entire green remodeling project, a total of 0.526 million ton water conservation was achieved.

Figure 5 Installation of outer sun-shading incorporating with solar cell system (Source: ABRI, 2004)

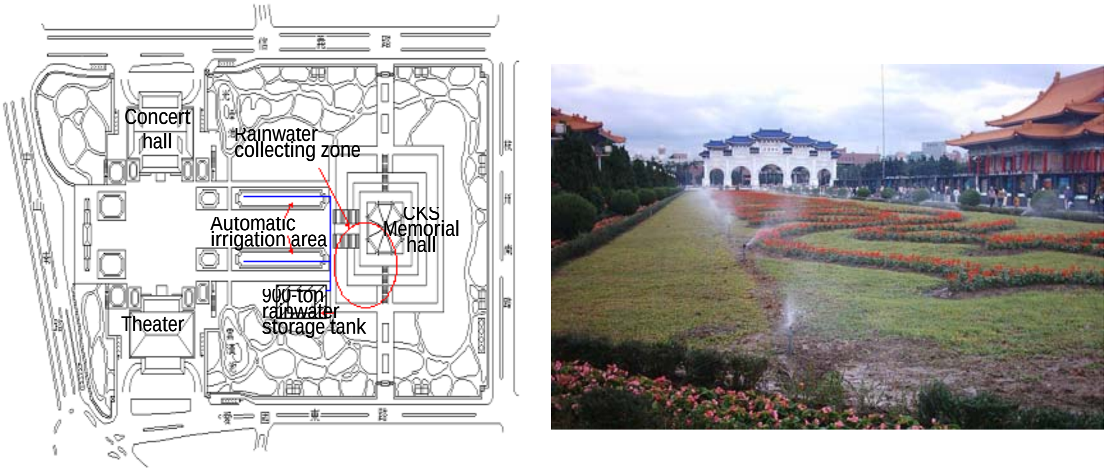


Figure 6 Rainwater utilization system in Chiang Kai Shek Memorial Hall (Left: Site plan; Right: Rainwater storage tank and relevant facilities installed to substitute tab water irrigation) (Source: ABRI, 2004)

2.2 Green HVAC Project for Governmental Buildings

The hot and humid climatic condition of Taiwan has imposed heavy cooling load on building HVAC systems. Chiller plants of the HVAC system often with over-sized design is a common problem. An over-sized chiller, which runs under a very low partial load factor, will result in poor energy efficiency, excessive investment in installation, and high operation costs. This kind of chiller plant not only needs to be downsized, but should also adopt a better-fitted chiller size combination so that optimal operational strategies can be applied during various load conditions. In addition, the chilled water distribution system is normally designed with constant speed pumps, which runs on their maximum capacities all the time, no matter how cooling load fluctuates. A Variable Water Volume (VWV) system, which can change the pumping speed by inverters, should be adopted to save pumping power during low load conditions. Furthermore, some ice storage air-conditioning systems, which can shift the on-peak power demand to off-peak hours and thus saves tremendous amount of operating costs, have been removed from commercial operation due to lack of proper maintenances, also presenting a huge loss of the investment. Therefore, the ABRI launched a demonstrative green HVAC project for governmental buildings from 2003 to 2007. Its examination procedure was, first, to measure the performance of existing systems. The second step was to analyze the air-conditioning load and its type. The optimal capacity for efficient operations was thus estimated. By the end of 2007, 97 projects were completed with successfully downsizing 14% chiller capacity from 19,100RT to 16,400RT and increasing 29% chiller operation efficiency. The results also showed that the payback of the retrofitting investment was about fiver years.

2.3 Building Envelope and Roof Heat Insulation Improvement Project

The consumption of energy by building envelopes is defined as the energy consumed by areas influenced by external climatic factors, thereby causing internal energy loss. Since Taiwan is located in tropical and subtropical regions, the air conditioning system that cools down the indoor temperature is indispensable to people’s daily life. It also, however, leads to more than 70% of the total energy consumption during summer. According to relevant studies of the improvement project, a building envelope covering a 5-meter depth in the peripheral area contributes 37.5% of the total energy consumption of air conditioning systems. Noticing that the existing building envelopes consumed large amounts of energy, the ABRI thus selected a total of 336 buildings with improvement potentials and subsidized the improvement work from 2002 to 2007. The introduction of energy saving design, such as window shading installation and roof heat insulation, into both governmental and private residential buildings was undertaken, including 116 cases of window shading and 220 cases of roof heat insulation, summarized in Table 2.

Table 2 Building Envelope Heat Insulation Improvement Project

Classification	Public sector		Private Sector	
Facilities	Roof Heat Insulation	Window Shading	Roof Heat Insulation	Window Shading
No. of Cases	36	56	184	60
Areas	30,712.2 m^2	6,920.3 m^2	28,697.3 m^2	2,497.5 m^2
Subsidies	78 million NTD*		32 million NTD	

* 1 NTD (New Taiwan Dollar) = 33 USD

Significant improvements have been observed in these cases, while a total of 195 million NT dollars has been input as subsidy. Through calculations, it has been found that 1.93 million degrees of electricity can be saved annually, equivalent to a 4.83 NTD saving with a conversion of 2.5 NT dollars for each degree of electricity. For the window shading facility, energy consumption was reduced by approximate 15% for air conditioners that would take 15 to 20 years to retrieve the subsidy. As for the roof heat insulation facility, 11% reduction for air conditioners at the top floor of the building was estimated, which would take 4 to 5 years to retrieve the subsidy.

2.4 Indoor Environmental Quality Diagnosis and Improvement Project

In general, people spend 90% of their time staying in the indoor environment, where the indoor environmental quality (IEQ) influences back to people's health. For example, poor indoor air quality may cause discomfort and even illness, such as sick building syndrome. Moreover, it may spread the contaminated mass to other people and offer a media space for the diffusion of contamination sources. Realizing the importance of the IEQ, the ABRI conducted an IEQ diagnosis and improvement project widely covering five major aspects: acoustics environment, illumination environment, thermal environment, air environment, as well as electronic/magnetic environment. The project included building doctor's diagnosis and physical improvement of the indoor environment. For diagnosis, three different stages were implemented, including self-examination, the preliminary walk-through, and the detailed investigation of the building from a healthy environment standpoint. Next, the process for conducting physical improvement starting with setting the goals of improvement involved a series of work of planning, design, construction, and re-assessment after completion. The project ranked the influence to human health by the five indoor environment aspects and the result showed that the sensitivity to the air in the environment was the highest (22%), followed by acoustic (14%), thermal (13.5%), illumination (12.9%), and electronic/magnetic (12%). By the end of 2007, the project was completed with 18 improvement cases that also provided for the industry as a reference.

2.5 Greening Existing Building Demonstrative Project for Private Sector

The greening existing building project was implemented by the Construction and Planning Agency of the Ministry of the Interior (CPAMI), particularly for the private sector. The project was started from 2004 according to the prior Green Building Promotion Program and is continuously executed and involved in the current Eco-City and Green Building Promotion Program. The CPAMI conducted the greening project based on the EEWH green building concepts and classified the scopes into building site, shell, indoor, and equipment. Applicants covering private schools, residential buildings, and office buildings showed a variety of green building techniques, such as rooftop garden for heat insulation, constructed wetland, permeable pavement, adaptable sun-shading devices, solar water heating system, air conditioning monitoring system, photovoltaic systems, HVAC efficiency improvement, IEQ improvement, water saving fixtures, rainwater and grey water reuse system, etc. By the end of 2008, a total of 56 cases were completed and showed an annual 837 thousand kilogram reduction of CO_2 emission. Figure 7 presents the geographical distribution of all improvement cases around Taiwan from 2004 to 2008. Figure 8 demonstrates a distinctive transformation of an ecological pond and surrounding constructed wetlands in Chia Nan University of Pharmacy and Science. Among the 56 improvement cases over the past five years, 146 improvement items were implemented, where energy saving techniques possessed 78 items accounting for 53% (as Figure 9). The statistics indicates that the private sector puts more emphasis on energy saving issues. Breaking into four scopes, the distribution pie charts show the focuses are water infiltration and retention, indoor illumination, HVAC system, as well as roof heat insulation, respectively (as figure 9).

Figure 7 Geographical Distribution of greening existing building projects in Taiwan from 2004 to 2008
(source: Construction and Planning Agency, 2009)

Figure 8 Campus transformation of an ecological pond and constructed wetland project in a before-and-after context (source: Construction and Planning Agency, 2009)

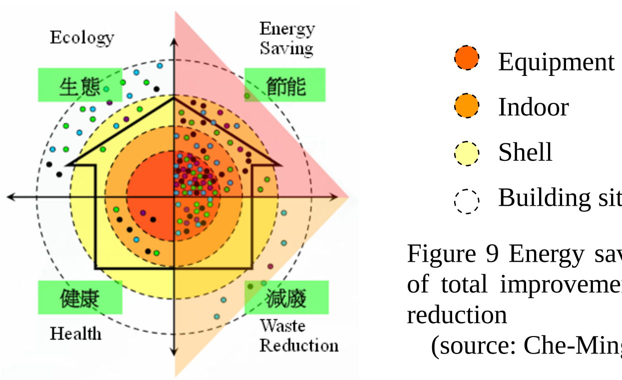
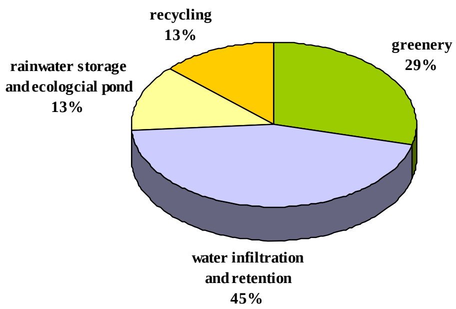
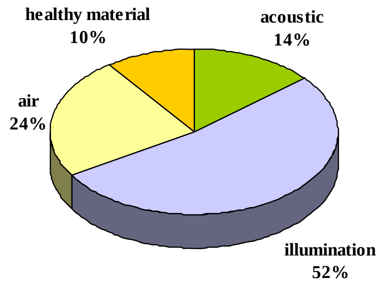


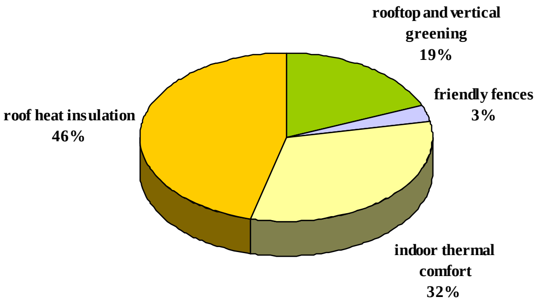
Figure 9 Energy saving techniques possess 78% of total improvement items, followed by waste reduction
(source: Che-Ming Chiang et al., 2008)



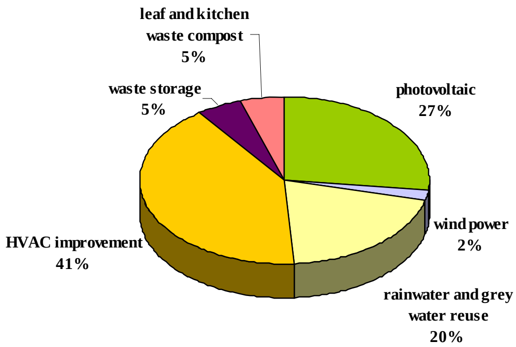
(a) Building site green techniques



(b) IEQ improvement techniques



(c) Shell greening techniques



(d) equipment greening techniques

Figure 10 Distribution of various greening techniques utilization for existing buildings (source: Che-Ming Chiang et al., 2008)

2.6 Green Diagnosis and Renewal Project for Existing Governmental Building

The project planned to be from 2008 to 2011is the second phase of the prior green remodeling project, focusing on green renovation on governmental buildings. The main purpose of the phase is to mitigate urban heat island effect through the integration of energy saving and ecological techniques. For example, the rooftop garden can not only be greening the environment, but also enhancing the HVAC energy efficiency and indoor thermal comfort of the top floor of the building. After the first year implementation, 14 projects were completed including green roof, outdoor trellis for sun-shading, outdoor illumination (for avoiding light pollution), sustainable water resource utilization, as well as water infiltration and retention improvement. The estimated CO_2 emission reduction was about 127 thousand kilograms annually. Figure 11 shows the application of green roof in the service center of Tai-Chung Metropolitan Park effectively reducing the roof heat penetration.

Figure 11 Before (left) and after (right) creating a rooftop garden in the service center of Tai-chung Metropolitan Park (source: ABRI, 2008)

2.7 Building Energy Efficiency Upgrade (BeeUp) Program

In the prior green HVAC project in the Green Building Promotion Program, one of the major improvement items was to replace the old chillers with new efficient ones having significantly achieving energy conservation but simultaneously investing in higher equipment installation. Yet the current phase of the BeeUp program (2008 to 2011) aims to improve the building energy with low-cost techniques and effective operation and management strategies. The scope of the program covers HVAC, lighting, and water heating systems. By the end of 2008, 38 improvement cases were completed with an annual 3.36 million kilogram CO_2 emission reduction. The results show that significant energy savings in the HVAC, lighting, and water heating systems are 22%, 37%, and 40%, respectively (as Figure 12).

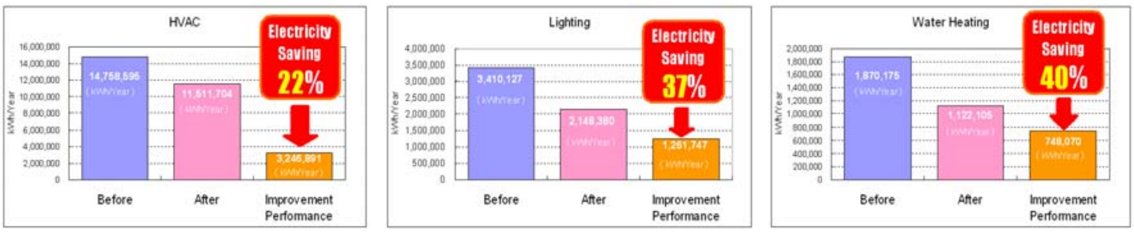


Figure 12 HVAC (left), lighting (middle), and water heating (right) system energy saving performance of the BeeUp program (Source: ABRI, 2008)

3. Conclusions

The green renovation projects described in the paper, though the amount of 658 projects is relatively few comparing with all of existing buildings, are mainly to motivate more participation of the private sector, particularly office and residential buildings. The greening techniques adopted in these improvement cases can also provide for the public and construction industry as practical references in building renovation, so that people can be benefited from energy saving and better living environment and the industry can be transformed in a greener way too. Through the improvement works, most of the buildings that were renovated based on the EEWH green building concepts did not, however, pass the certification of the Green Building Label of Taiwan. One of the reasons was that these renovation projects selected some techniques part of the entire EEWH system and were thus unable to pass the threshold of green building certification. The other one would be that the current EEWH system and labeling mechanism were essentially designed for new construction. The scoring methods and weighting factors for evaluating existing buildings should possess different characteristics from new buildings. Therefore, for widely promoting green renovation of existing buildings, the EEWH system for existing buildings (EEWH-EB) and its certification requirements will need to be further established.

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Yuan-Liang Cheng is the Director of the Environmental Control Division of the Architecture and Building Research Institute, Ministry of the Interior, Taiwan. Dr. Cheng was appointed to this position in April 2009. Having abundant experiences in the field of building design, management, and regulations, Dr. Cheng completed the green building institutionalization work in Taiwan from 2004 to 2009. He is currently implementing the policy of green building and eco-city development, and supervising the technology research plan of green building and sustainable built environment.