從低碳建築到零碳住宅 LowtoNo-以金門獨棟民宅為例

from low carbon building to no carbon house - LowtoNo

use of a single-family house in Kinmen as an example

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1.1 興建背景 Background

近年來極端氣候發生的頻率增加以及哥本哈根會議，已經改變世人對環境問題的態度，特別是氣候變遷導致地球暖化，溫室氣體減量已是二十一世紀全球共同關注之議題，其中又屬二氧化碳減量最為世人關注，然而大多數潛在的低成本溫室氣體排放量（碳）是隱藏在所謂建築環境中，因此低碳建築被許多人看作是一個關鍵途徑，提供大幅度削減二氧化碳的排放量，低碳建築便成為建築業界最主要發展的課題。台灣建築相關產業使用能源的二氧化碳總排放量，約佔全國總排放量的 28.8% [1]，以碳足跡來衡量建築物之興建，便占二氧化碳總排放量近 1/4，從建築行業的溫室氣體（GHG ）排放量已超過 1970 年以來，以加倍達到 9.18 $GtCO_2eq$，在 2010 年佔總排放量的 25 %，而非農業、林業和土地利用（AFOLU ）部門 (IPCC，2014) ，足見低碳建築之興建使用已成為先進國家建設發展重心所在。致於零碳生活之推廣，各國家大都止於低碳層面，尚未觸及零碳界面，本書最大特色是以低碳建築為平台，藉由搭配建築之低碳策略進行所謂低碳生活之規劃，也就是把建築減碳概念配合低碳生活發展至零碳層面，減碳範圍擴大至建築全生命週期，希望能達成所謂零碳生活終極目的。

In recent years, the increased frequency of extreme weather and the Copenhagen Summit have changed the attitude of the public towards environmental issues. In particular, climate change has a significant impact on global warming; therefore, reduction of greenhouse gas emissions has become a global concern in the 21st century, and reduction of carbon dioxide is an issue of concern worldwide. However, the majority of potential low-cost greenhouse gas emissions (carbon) are hidden in the building environment. Therefore, low-carbon building is seen as a key way in which to reduce carbon emissions, as it can substantially cut carbon dioxide emissions. Thus, low-carbon building construction has become the main aim in the development of architecture and the construction industry. In Taiwan, the total energy used by construction-related sectors represents 28.8% of the total carbon emissions nationwide [1]. According to the carbon footprint, building construction accounts for a quarter of the total CO_2 emissions. In terms of CO_2 emissions, direct and indirect emissions caused by construction, electricity usage and other energy usage for buildings account for about 21% of the national total carbon emissions, which is second only to industrial emissions. Greenhouse gas emissions from the building industry have more than doubled since 1970, reaching 9.18 $GtCO_2eq$ in 2010 (Figure 2.1), which accounts for 25% of the total emissions, not taking into account the agriculture, forestry and land use (AFOLU) sector. Construction of low-carbon buildings has therefore become a focal point in developed countries. In terms of the promotion of zero-carbon living, most countries adhere to a low-carbon national level, but few are focused on achieving a zero-carbon environment. The most important feature of this book is the use of low-carbon buildings as a basis and extending this to achieve zero-carbon buildings by introducing a low-carbon lifestyle that can further improve carbon reduction.

2.4 國內低碳建築案例 Low carbon building in Taiwan

圖 2.5 台灣成功大學綠色魔法學校模擬圖
Figure 2.5 Illustration of the Magic School of Green Technologies, National Cheng Kung University. (http://www.msgt.org.tw)

1) 台灣成功大學 - 綠色魔法學校

2011 年 1 月 12 日，正式落成於台灣成功大學力行校區的「綠色魔法學校」(圖 2.5)，這全球最節能的「綠色魔法學校」，每坪造價只有 8.7 萬元（現有辦公建築一般造價），是一般人都負擔得起的「平價綠建築」。它採用了 13 種綠建築設計手法，達到難以置信的節能 65%目標，包括五種建築本體與自然通風的軟性節能手法，兩種設備減量的方法，五種設備節能技術以及再生能源技術。其中最特別的是採用自然浮力通風的技術，讓一座 300 人國際會議廳在冬季四個月可以不開空調，達到空調節能 28%，採用空調與吊扇並用設計，讓辦公區空調節能 76%；採用陶瓷複金屬燈二次反射照明設計，讓國際會議廳達到節能四成的水準。在此雖然有三分之一是稍貴但回收年限在三年以內的高效率節能設備，另外有一半以上的綠建築創意都是不花錢又可立即回收的「平價技術」，是最值得推廣落實的「平民綠建築技術」。(http://www.msgt.org.tw)

1) The Magic School of Green Technologies, National Cheng Kung University, Taiwan

The Magic School of Green Technologies is located on a campus of National Cheng Kung University, Taiwan (Figure. 2.5). The cost of the building was only NT$ 26,400/m2 (~US$ 880/m2), which is similar to the average cost of a conventional office building. Therefore, it is affordable, and is the most effective energy-saving green building in Taiwan. It employs 13 kinds of energy-saving designs to enable the green building to achieve an energy-saving target of 65%. The designs include five methods of energy-efficient ventilation techniques, two types of equipment to reduce resource usage, and five energy-saving and renewable techniques. Of these techniques, one highlight is that the 300-seat conference room does not need to use air-conditioning during the 4 months of winter, which saves 28% of air-conditioning usage. The building utilizes a combination design of air-conditioning and ceiling fans, which saves 76% of air-conditioning use in the office area. In addition, the conference room features ceramic discharge metal-halide lamps, which can save 40% of electricity usage in the lighting system. Although some of the designs cost more to implement, the investment can be balanced within three years. Moreover, many creative designs that are suitable for use in any green building do not cost more, and can immediately save energy (http://www.msgt.org.tw).

2) 台灣中壢私人住宅低碳改造

在台灣中壢之既有住宅有別於傳統外牆磁磚敲除重貼之方式（外牆拉皮），改以附掛複合式外壁（外牆穿衣）進行整建（圖 2.6），除立面美化外，也一併改善外牆隔熱保溫程度，為一樓室內溫度環境品質提升到26℃左右（夏季戶外溫度 32℃以上），然後依次樓層向上各提高 1℃之環境溫度，亦即第四層室內溫度為 29℃（此樓層屋頂為雙層鐵皮構造），將來如加設太陽能光電模組後，其室內溫度可望下降至少 2℃以上；改造後整體將減少室內空調之損耗及傳統建築物拉皮所產生的建築廢棄物，以符合政府節能政策及廢棄物減量之觀念[18]。

本書並於最後節錄此棟同樣由作者設計改造的建築興建過程，以不一樣的工法做一比照。

圖 2.6 改造前及改造完工後外型及庭園情況
Figure 2.6 Photos of the residential home before and after renovation.

2) Low carbon renovation of a residential home in Zhongli, Taiwan

Another project of this study was to renovate a residential home located in Zhongli, Taiwan. To restore the facade of the house, instead of re-installing new tiles on the exterior walls, a new layer of composite exterior wall panels was installed on the building envelope to improve the insulation of the house (Figure 2.6). In addition to improving the overall appearance of the building, it also increased the insulation. The design decreased the indoor temperature to 26°C (with an outdoor temperature higher than 32°C) in the summer on the first floor. The upstairs indoor temperature was 1°C higher than that of the downstairs. The fourth floor (the top floor) is currently 29°C, but is expected to reduce by 2°C when a solar photovoltaic module is installed on the rooftop. This renovation method not only reduces air-conditioning usage, but also reduces the amount of waste materials created during the refurbishment, which complies with the government's energy policy and the concept of waste reduction[18].

In the final chapter, the process of construction of another residential home is described, and the different construction methods used for these houses are compared.

圖 2.7 修繕前建築外觀
Figure 2.7 Building exterior before renovation.

圖 2.8 完工後立面太陽能建築一體（BIPV）複層式外牆的模式
Figure 2.8 Building-integrated photovoltaics (BIPV) were installed, with a composite wall design.

3) 福建省金門地區稅捐處

在金門第一棟建築面貌改善示範建物 (圖 2.7)，針對建築物四周外牆以穿衣的方式取代傳統拉皮（複層式外壁），改善外牆之隔熱保溫程度，並減少傳統建築物拉皮所產生的建築廢棄物，以符合金門低碳島推動減廢觀念；屋頂利用浮石隔熱，阻隔由屋頂傳導下的輻射熱能，提升室內溫度環境品質，同時降低空調費用支出；以 BIPV 建築一體方式於建築物立面外掛太陽能光電模組及頂樓露台架設小型風力發電設備 (圖 2.8)，作為開發綠色能源及節能減碳概念推廣示範案例；外牆隔熱保溫效益將為稅捐處冬季之室內平均溫度提升 2~5 度、夏季降低 5~7 度，而綠色能源之應用每年將可創造 6,957 度電，減少約 3,659 公斤二氧化碳排放量 [19]。

3) Tax bureau building, Kinmen County

In order to respond to Kinmen's directive regarding the reduction of building waste and carbon emissions during building renovation, the Tax bureau building of Kinmen County (Figure 2.7) was the first façade renovation project to demonstrate waste reduction and energy efficiency improvement to the general public in Kinmen. Instead of replacing building surface materials, it employed installation of composite exterior wall panels on the building envelope to improve the insulation, and the placing of a layer of lightweight pumice stopped radiant heat from being transferred into the building from the rooftop. The electricity generated from the building integrated photovoltaic (BIPV) modules on the façade and small wind turbines on the rooftop (Figure 2.8) is renewable energy and reduces carbon emissions. The newly-installed building exterior walls have helped to increase the temperature by 2-5°C in the winter and reduce it by 5-7°C in the summer. Overall, the green renewable energy accounts for 6,957 kWh of electricity annually, which is equal to a reduction of 3,659 kilograms of CO_2 emissions[19].

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