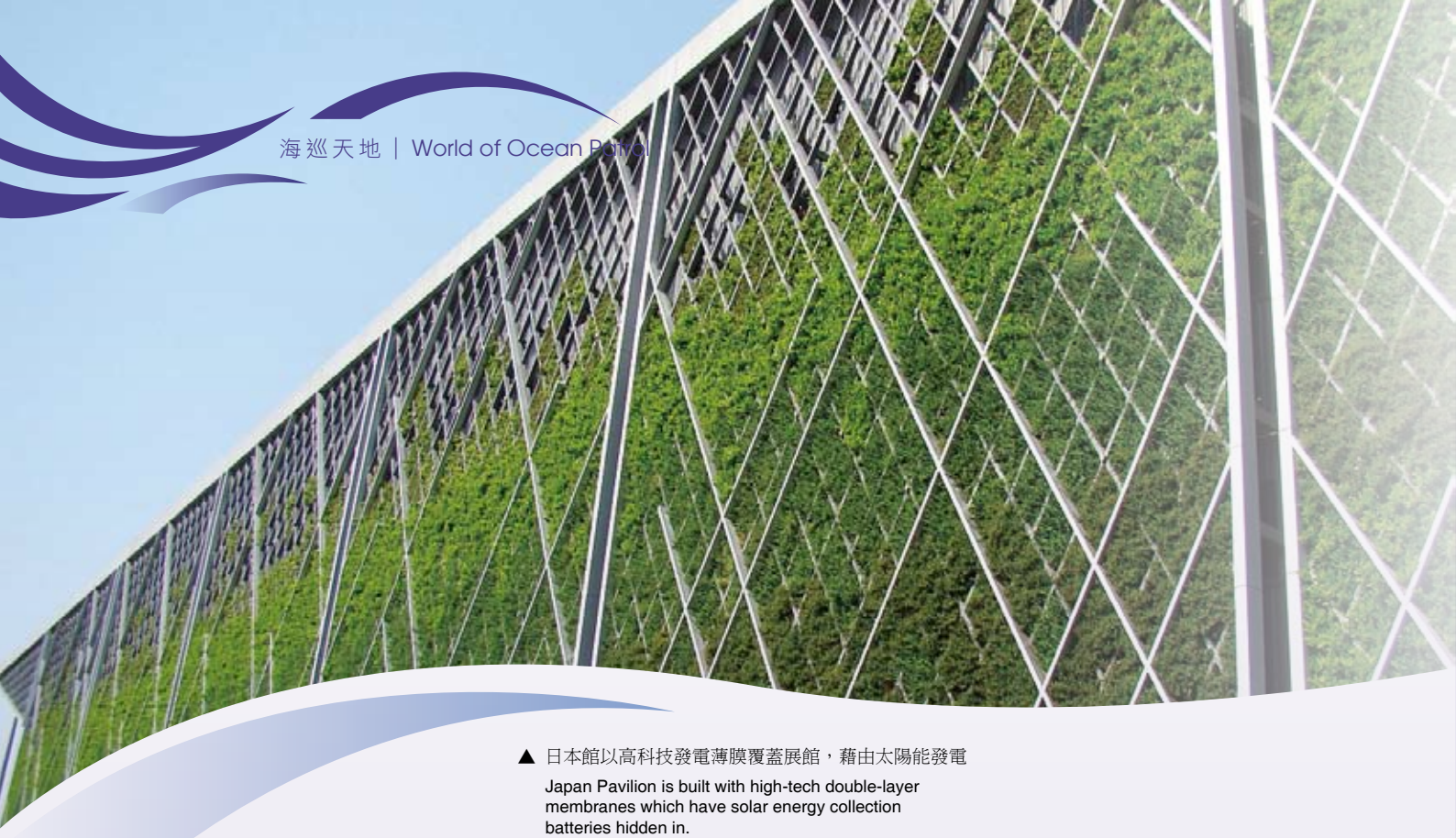

▲ 日本館以高科技發電薄膜覆蓋展館，藉由太陽能發電
Japan Pavilion is built with high-tech double-layer membranes which have solar energy collection batteries hidden in.

從2010上海世界博覽會看見節能減碳新趨勢

Recognize the New Trends of Energy Conservation and Carbon Dioxide Reduction from Expo 2010 Shanghai China

文、圖｜陳泰廷
Article,photos | Chen Tai-ting

節能減碳是政府當前重要施政方針之一，也是全人類必須共同面對的挑戰。地球資源有限，「不願面對的真相」終究會達到臨界點，因此，各國政府為了永續資源利用，紛紛以節能減碳為施政重點，發展新興能源與綠色產業，行政院亦於98年修訂「行政院所屬機關中長程個案計畫編審要點」時，將「碳中和」概念納入規定，要求各新增計畫落實執行。世界博覽會向為各國展示其強大國力、創新與科技的舞台，如果說奧運比的是體技，那世界博覽會比的就是智力。1851年英國舉辦第一屆世界博覽會，迄今已有159年歷史，許多影響世人生活、工商發展的重大發明，都是在世界博覽會初次與世人見面後，才廣為各國採用。例

As one of the government's important administrative policies, energy conservation and carbon dioxide reduction also means a universal challenge to all mankind. Since earth resources are limited, the "Inconvenient Truth" will eventually reach the critical point. To realize sustainability, the government of each state takes energy conservation and carbon dioxide reduction as the emphasis of administration, one after another, with a purpose to develop new energies and green industries. The Executive Yuan in 2009 amended the"Emphasis of Development of Long and Medium-range Individual Plans of Institutions under the Executive Yuan", into which the concept of"Carbon Neutral" was introduced, requiring implementation by the new plans. World Expo is a platform of demonstrating national strength, innovation and technology. If we regard Olympic Games as

如洲際高速公路的概念，就是通用汽車在1939年紐約世界博覽會提出的概念，從此開啟了各國商業貿易與行動運輸的新頁，其餘如愛迪生的電報機、貝爾的電話、柯達的軟片、蒸氣機、打字機、摩天輪等，甚至小自甜筒冰淇淋與熱狗漢堡、大至巴黎鐵塔與自由女神，都曾在世界博覽會的舞台發光發熱，翻開世博百年史，盡是人類最輝煌的成就與驕傲。筆者身為世博迷，本次前往上海世界博覽會，為善用每一分、每一秒，整體行程採計畫性作為，期能在有限時間內，吸收最精采的內容，並置參觀重點於節能減碳之趨勢與創新，希望能藉由各國對綠色產業的重視與規劃，提出淺略心得，供爾後相關計畫建案時納入參考。

世界博覽會是三年一度的國際盛會，2010年5月1日至10月31日在上海黃浦江兩岸舉辦，面對龐大的華人市場，各參展國家在籌備期間，即便遇到世界金融海嘯，仍是卯足全力展現國家特色，甚至不惜加碼投資，要在這個世界級的腦力創新大賽中，激盪出國家特色。台灣自參加1974年美國史撥肯世界博覽會後，本次再度重回世界博覽會舞台已經36年光陰。本次上海世界博覽會在開幕前已經創造很多紀錄，諸如242個國家與組織的參展，歷來最多;園區建設不含各國展館，投資約新台幣838億預算，為史上最貴、全球最大太陽能單體建築面積、全球最大LED展區等，而且可能繼續再創下其他記錄，例如最多參展人數、最多藝文展演活動等。綜攬各個饒富巧思的展館，在國際大師級建築事務所的精巧設計中，無論是國家展館或城市實踐區，處處可見節能減碳概念，以下僅就所見提出幾點心得分享：

physical-oriented, then we can say World Expo is intelligence-oriented. With a 159-year history since the Britain World Expo in 1851, it has introduced many major inventions influential to our life and business development. For example, the concept of intercontinental expressway, by General Motors in 1939, on the New York World Expo, which opened a new page of commercial trade and transport operations; as well as Edison's telegraph, Bell's telephone, Kodak's film, steam engine, typewriter, Ferris wheel, and even the small ice cream cones and hot dogs, hamburgers, the large Eiffel Tower and the Statue of Liberty, all of which ever went on stage of World Expo. The history of Expo is full of mankind's most glorious achievements and pride. As a fan of Expo, to make good use of every minute, and every second at Shanghai World Expo, the whole trip is well planned for the most interesting content, with focus on energy conservation and carbon dioxide reduction, including the trends and innovations therein. Learn from different countries on ideas and planning of green industry, and present a little shallow experience as references for future plans and projects.

World Expo is a three-yearly international event. From May 1 to October 31 of 2010, it is held in Shanghai, on both banks of Huangpu River. Facing the huge Chinese market, the participating countries have come over the global financial tsunami during the preparatory period, and even made a big push to show national characteristics. They even added investments to, at this world-class intellectual innovation contest, bring out the national flavor. It has been 36 years since the participation of World Expo 1974 Spokane last time, Taiwan steps on the stage of Expo once again, this year. The Shanghai World Expo has, before its opening, created many records, e.g. 242 participating countries and organizations, park investment excluding pavilion buildings goes high to NTD 83.8 billion, the world"s largest single building of solar energy, and the world's largest LED exhibition area, etc. It may continue to scale other new records, such as the number of exhibitors, the amount of arts activities and so on. Among the pavilions of memorable ingenuity, in the great design of international master-level architectural firms, both at national pavilions and urban practice areas, the concept of energy conservation and carbon dioxide reduction may be recognized everywhere. The following tips are made for share：

一、綠色能源將成為爾後新能源趨勢

綜觀整個世博園區，區分A、B、C等三個國家展館區，以及D、E等兩個企業與城市實踐區，所使用之運輸工具與空調，有50%以上係採用所謂的綠色環保能源。例如，為解決上海夏季常達攝氏40度的溽暑高溫，整個世博園區底下埋了近三萬平方公里的冷水管，引導黃浦江水面五公尺以下的冰冷江水，透過熱交換的方式，成為展館的自然空調來源；此外，各國展館為呼應「科技世博、低碳世博」的理念，其空調亦多採用「儲冰式空調系統」，在夜晚用電離峰時間以壓縮機冷卻水成冰，白晝時間再以融冰所釋放的冷氣，來達到冷房效果；LED照明系統則是世博園區大規模採用的綠色科技；太陽能發電也是重點項目，廣佈在各展館屋頂四周的太陽能板，甚至有「紫蠶館」美稱的日本館，外表更採用新世代高科技「發電膜」；另如部分展館採用「透明混泥土磚」，藉由陽光直接透射入屋，減少室內燈光需求；以及自然雨水收集再利用、大豆製成的燈具產品、海浪發電設備等，處處可見綠色能源運用與節能減碳成果的蹤跡。

二、實體外牆由綠色植匹覆蓋

在使用綠色能源的同時，部分展館採用了更前端的概念，也就是減少熱源吸收進入大樓，即可進一步降低空調的使用率，因此有多個展館，例如法國館、主題館以及部分城市實踐區的城市館，都可以看見綠色植匹垂直覆蓋的情形，同時產生遮蔽陽光與阻斷熱源效果，並兼具吸收二氧化碳與視覺美觀的效果。這看似簡單的綠色植匹，在強大地心引力的牽引之下，經過多次的試驗與失敗，已成功克服灌溉系統之主要關鍵。平面式的綠色植物可用自動灑水器完成澆水任務，而垂直式的植物牆，克服地心引力所造成的缺水問題，則是本項技術的關鍵。

I. Green energy will be the new energy trend thereafter

In the whole World Expo site including A, B and C country pavilion areas, and D , E enterprise and urban practice areas, more than 50% of transport tools and air-conditioners use so-called green energies. For example, to solve the hot summer of Shanghai, under the World Expo site are buried nearly 30,000 square kilometers of cooling water pipes, which utilizes the cold water under the Huangpu River as the natural air-conditioning source for pavilions; In addition, following the idea of "High-tech & Low-carbon", most country pavilions adopt the"ice-storage air-conditioning system" which off-peak at night uses the compressor for cooling water into ice, and daytimes melts ice for air-conditioning; LED lighting system is the green technology with large-scale adoption at World Expo site; solar power is also a key project, the solar panels are widely distributed around the pavilion roofs, and the Japan Pavilion honored as "Purple Silkworm Island" museum even adopts new high-tech of "power-generation film"; some pavilions use"transparent concrete brick" which enables the direct transmission of sunlight, reducing demand for indoor lighting; and there are also natural rainwater collection and reuse, lighting products made from soybeans, wave power generation equipments and so on, highlighting the use of green energy and the traces of carbon dioxide reduction.

II. Solid outer wall covered with green plants

While using green energy, some pavilions adopt more front-end concept, namely to reduce the heat absorption into the building, and reduce the using of air-conditioner. Several pavilions such as France Pavilion, Theme Pavilion, and some city pavilions within urban practice area are covered with green vegetation vertically, which shields the sun and blocks the heat, as well as absorbs carbon dioxide and achieves visual aesthetic results. This seemingly simple green vegetation is under the strong gravity traction, it has experienced many times of experiments and failure, and the irrigation system is the key issue. Planar-type plants can be watered by automatic sprinklers, but vertical wall of plants have to overcome water shortage caused by gravity, this is the key technology.

◀ 垂直式植匹仰賴特殊澆水系統可阻斷熱源
Walls masked with plants vertically when using special watering system can block the heat.

▲ 微藻除碳應用於屏風之實況
The application of adding microalgaes on screen to reduce carbon emissions.

◀ 園區內一律採用電動車作為運輸工具（車頂上方為充電系統）
The only intra-site transportation is storage battery cars. (Car roof is the charging system.)

三、微藻除碳

地球生物奧妙萬分，目前所知或僅其冰山一角，近年綠色產業中，有號稱綠色明星產業的「微藻」，在世博園區中亦可窺見其應用，台電公司目前針對此項技術亦積極培植中，例如早於2007年，台電高雄大林電廠，即已進行螺旋藻除碳的實驗，微藻除碳技術目前仍限於商業規模與開發成本，尚未能全面量產，爾後若能廣泛運用，當可為地球環保貢獻心力。

四、電動車輛

世博園區廣達5.28平方公里，約略小於永和市面積，光靠腳程甚難完成園區參觀，因此世博園區為解決遊客運輸問題，園區內提供免費公交車（即公共運輸車輛），無論是大型的公交車或小型的觀光車，一律採用電動能源，減少園區內二氧化碳產生，在多個展館中，亦展示電動汽車技術。面對石油存量有限的現況，各國與相關汽車大廠均已研發因應之道，相信本次世博所呈現的電動能源車，甚至車與車之間的網路通訊，不久的未來都可能發生在生活周遭。

五、海洋發電

馬總統提出「藍色革命、海洋興國」政策，所謂海洋興國，不只是海洋產業上的發展、海洋文化科教的推廣，更要廣泛的從心裡層次接受海洋、妥善運用海洋。本次世博行程中，在「全球青年創新之旅」展館中，就展示一款名為海蛇（Pelamis）的海浪發電機組，藉由一種環狀連結的器材，利用海浪、海流所造成的擠壓，將海水進入到內置汽缸，以動能轉化為電能，再聯結到岸上儲存使

III. Microalgae for carbon dioxide elimination

Life on earth is rather profound, and what we know is only a tip of iceberg. In the green industry of recent years,"microalgae" is known as green star industry. In the Expo site, we can also see the application of this technology. Teclast Electronics is actively engaged in cultivation of this technology. As early as 2007, Teclast Kaohsiung Dalin plant started related experiments of microalgae. Restricted by commercial scale and development costs, it has not come into full production. Its widely application if possible will make much contribution to global environmental protection.

IV. Electric vehicles

Expo site covers 5.28 square kilometers, slightly smaller than Yonghe City. It is difficult to complete visiting the park on foot, there is equipped with free bus service (or public transport vehicles). All the large tourist buss or small sightseeing trucks adopt electric energy, to reduce carbon dioxide generated within the park. A number of pavilions also demonstrate electric vehicle technology. Due to the limited stock of oil, countries and auto makers have been developing the alternatives. I believe that the electric energy vehicles and even vehicle network communications here will, soon, occur in our daily life.

V. Ocean power generation

President Ma has put forward the policy of "Blue Revolution, Prosperity with the Ocean". Regarding the so-called ocean prosperity, we shall not only develop the marine industries and promote the marine science and education, but accept the sea heartily and make proper use of ocean. In the pavilion of "Global Youth Innovation Tour", there is a Pelamis-named wave power generator, that is, the equipment of cyclic link uses the waves and currents, guides the seawater into the internal

用。相同概念尚有潮汐發電等，本次世博園區並未展示，依個人淺薄認知，可能係因為潮間帶物種繁多，所造成的生態影響層面較近海設置、甚至水面下亦可裝設的「海蛇」更大，衷心期盼海浪發電的技術能更趨成熟，如此，台灣四周惡名昭彰的「惡水」環境，如富貴角、三貂角以及鼻頭角等浪區，將可提供新一代乾淨能源。

世界博覽會是先進科技以及未來趨勢展示的重要舞台，本次2010上海世界博覽會以「城市，讓生活更美好（Better city, Better life）」為主題，「科技世博、低碳世博」為理念，所具體呈現的展示內容，當可為爾後日常生活運用，或承辦業務重要參考來源。強如美國海岸防衛隊，在2010年提交的預算報告中亦揭示，將成為更綠能環保的海岸防衛隊（A Greener Coast Guard），例如Petaluma訓練中心已裝設4英畝的太陽能發電板（solar energy），另外Cap May訓練中心也將建設能發電1.6百萬瓦的風力發電機（wind turbines），足見綠色科技確為潮流所趨。

向為世界產業科技先趨的世界博覽會，下次將於2012年假韓國麗水舉辦，其主題就是「海洋」。自1996年12月9日聯合國大會決議，請聯合國秘書長擴大原海洋法報告內容，每年向聯合國大會提出海洋與海洋法報告後，原本已為報告重點的劃界爭議部分，隨著2009年5月各國提交聯合國大陸礁層界限委員會，有關該國大陸礁層外界限的科學調查資料，海洋權益的爭議絕對是未來國家權益的重點戰場之一。2012年韓國麗水舉辦的世界博覽會，將由科技研發、產業發展、觀光休閒、海洋綠能等諸多面向探討海洋，對於此一海洋國際盛會，同於2012年揭牌成立的海洋委員會要以何種角度面對，應為值得深思的議題。

(本文作者任職於海岸巡防署企劃處)

cylinder, turns the kinetic energy into electricity, and connects the latter to the shore for storage and using. Tidal power generation is one of the similar concepts, but it is not shown on this Expo, maybe due to that there are too many inter-tidal species, and the ecological impact is much higher than that of Pelamis at offing or even underwater. I hope the tide power technology to be more mature, then the notorious "turbulent waves" environment around Taiwan, like Cape Fukuei, Cape San Diego and Cape Bitou will be able to provide a new generation of clean energy.

World Expo is a display of advanced technology and future trends. The 2010 Shanghai World Expo takes "Better City, Better Life" as the theme, and the "High-tech & Low-carbon" as the idea, and the specific content presented here are important reference sources for daily life and business thereafter. As for the U.S. Coast Guard, its 2010 budget report submitted reveals that it will become a Greener Coast Guard. Its Petaluma Training Center has installed four acres of solar panels, and its Cap May Training Center will be equipped with 1.6 million watts of wind power generators (wind turbines), which indicates the green technology as a trend indeed.

As the pioneer of industry technology, the World Exposition will be held in Yeosu of Korea next time, in 2012, and its theme is "Ocean." Pursuant to the UN General Assembly resolution on December 9, 1996, the United Nations Secretary-General expands the original report of ocean law. The ocean and ocean law report is now being reported to the UN General Assembly every year, and the section of frontier demarcation dispute is, in May 2009, submitted to the United Nations Commission on the Limits of the Continental Shelf (CLCS). Then, the scientific survey data on continental shelf boundaries of this country, as well as the disputes of marine rights and interests are definitely the focus of future battlefield of national rights and interests. The Expo Yeosu Korea 2012 will explore the ocean from such aspects as technology development, industrial development, tourism and leisure activities, and marine green energy, etc. Regarding such an international event of ocean, the attitude of Marine Committee to be established in 2012 is worthy of deep consideration.

(The author is currently with the Department of Planning, Coast Guard Administration.)

◀ 海浪發電系統－海蛇測試實況

Wave power generation system, sea electronic testing situation.