

# 中技社

通訊

123

CTCI QUARTERLY 民國106年 秋季刊

2017境外研究生企業參訪活動報導  
及學員心得分享

台灣能源經濟脆弱度

糧食、能源、水資源鏈結(FEW Nexus)  
發展趨勢與應用潛力

穿梭時空的手繪城市速寫



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## 編輯手記

本社為增進在台研修之境外生對台灣企業的了解，於 2014 年首度舉辦「境外研究生企業參訪」活動。今 (2017) 年甄選出 60 位研究生，分批於 7 月 5 日、8 月 23 日兩梯次，展開三天兩夜的行程。第一梯次有來自歐美非亞洲及中東等 14 國共 29 位境外生參與，行程包括東元電機、士林電機廠 (重電廠)、華城電機、宏全國際 (無菌飲料廠)、友嘉等企業觀摩，並拜訪經濟部招商投資服務中心；另安排參觀 921 地震教育園區、彩虹眷村及內灣合興車站等景點。經由此活動，促使在台境外生於埋首研修之際，有機會認識台灣企業國際化的布局與人力需求，以及境外生留台發展的機會與條件，並親身體認台灣的地景、文化與生活。

近年來我國面臨備用容量率和備轉容量率持續偏離最適值，且區域供電吃緊；再加上核四封存、再生能源供電不穩定、天然氣來源與安全存量的不確定性，以及火力發電可能導致的溫室氣體排放等因素，未來限電夢魘將如影隨形。有鑒於各界對未來能源危機之關切，本社於今年 8 月 10 日召開「我國能源安全指標研討會」，財團法人台灣經濟研究院、行政院原子能委員會核能研究所等國內重要能源政策智庫，分別於會中發表研究成果。此外，亦邀集國內產官學研專家以圓桌論壇方式，分析目前國內能源現況及產業需求，並提出若干具體的中長期政策，作為政府能源政策走向之建言。

水、糧食、能源向來都是全球探討的重要議題，若要解決問題，勢必要以糧食 - 能源 - 水鏈結進行整體思考。為了解三者間的競合關係，本社舉辦專題研討會與座談會，並出版「糧食、能源、水資源鏈結 (FEW Nexus) 發展趨勢與應用潛力」專題報告。目前的研究多半重視各鏈結問題，如量的平衡，偏向直接供給與消耗，事實上，間接消耗量亦必須納入考量。因此，未來將以生命週期思維考量，建構全階段的環境衝擊比較，再輔以經濟價值的估算，進行周全的可行發展方案比較。





企劃暨工程科技室 楊顯整代主任·鍾侑靜副管理師

本社為增進在台修讀博、碩士學位之境外研究生對台灣企業及環境有更多的認識，特別安排參訪台灣優質企業之活動，實地了解企業之經營實況及雙向交流討論；期使對台灣企業有更深入的瞭解，進而提升境外生加入台灣企業的意願，同時協助企業網羅優秀的國際人才，創造雙贏局面。

本社於 2014 年首度試辦在台境外研究生企業參訪活動，截至 2016 年吸引來自 31 國約 210 名境外研究生報名活動，累計共甄選出 116 名境外研究生參訪我國優良企業。今 (2017) 年持續辦理「境外研究生企業參訪」活動，共收到來自 20 個國家、19 所大學，143 位之境外生報名 (包括博士生 61 位及碩士生 82 位) 角逐兩梯次共 60 位活動名額，顯示本活動及成果已獲得境外生及企業之認同。

今年度第一梯次特別安排參訪在業界頗具盛名、深具實力的五家優質企業，依參訪順序為東元電機、士林電機廠 (重電廠)、華城電機、宏全國際 (無菌飲料廠)、友嘉實業等 (股) 公司，以及拜訪經濟部招商投資服務中心。透過參訪企業深入介紹企業經營的理念、產品特色及核心價值，與雙方的交流問答，以及帶領學員走訪廠區參觀實際運作，讓學員打破書本的局限，讓課堂所學知識與實際營運生產運作連結，從實務面拓展學員的視野，預見未來進入企業的工作情況；企業除了可近距離觀察參訪學員的個性及潛力，找到相互適配的優秀人才之外，同時亦可藉此推廣，提高企業知名度。

本活動為加深學員對台灣風景及人文的感受及體驗，特於第三天規劃不同面向的參觀行程，包括 921 地震教育園區、彩虹眷村及內灣合興車站等景點，讓境外生感受台灣的真善美、以及對生活的認真與對土地的憐惜。以下摘錄本梯次 29 位同學參與企業參訪活動的心得感想與眾同享。

CTCI Foundation was established in 1959 as a non-profit organization to serve the greater good

by training technical talents as well as improving industrial and national productivity. For international graduate students, CTCI Foundation has been arranging visits to Taiwan's prominent enterprises which are representative of their industries and also in need of international talents. The main goals of the visit are to foster a deeper understanding about prospects of Taiwan's corporations and working environments, and bring together positive interactions between corporations and international students. It is hoped that through learning business philosophy and vision of Taiwan's representative corporations and industry development, international students will make plans to pursue careers and join these corporation's in Taiwan so as to foster a win-win situation for all parties.

2014 had marked the first attempt of Enterprise Visit activity by CTCI Foundation. Up until 2016, a total of 210 international graduate students from 31 countries had applied for the activity, and a total of 116 graduate students have visited various representative corporations in Taiwan. The tremendous effort by CTCI has gained a wide recognition and notice by both corporations as well as international graduate students. For the year of 2017, the Enterprise Visit activity received applications from a total of 143 distinguished graduate students from 20 different countries which are studying in 19 universities in Taiwan. In short, these 61 Ph.D students along with 82 Master students have to compete for just 60 available slots.

For Tier One of 2017 trip, the arrangement for enterprise visits includes TECO Electric & Machinery Co., Shihlin Electric & Engineer Corporation, Fortune Electric Co., Ltd., Taiwan Hon Chuan Enterprise Co., Ltd., and Fair Friend



Enterprise Co., Ltd. All of these companies have developed great technological advancement and are representative of their industries. On the other hand, the governmental agency of InvesTaiwan Service Center walks students through investment options. It is hoped that through learning of vision, business philosophy, core value, and product strengths of corporations, Q&A session interaction, and actual walk-through of factory operation, these international graduate students can connect academic learning with actual industrial realities as well as operations in an effort to broaden their mindset and understanding. On another level, this also helps them to anticipate what actual working criteria and conditions might apply if they were working as the staffs. As for the corporations, they get to observe student participants' personalities and potentials in the matchmaking process. As corporations search for suitable candidates, they also get to promote reputation and brand names of their companies world-wide.

To help foster an understanding of Taiwan's beautiful scenery and local artistic developments, activities on the third day include special visits to Earthquake Museum of Taiwan, Taichung Rainbow Village, and Hexing Train Station. These sites represent aspects of Taiwan's natural beauties and the appreciation for the land that we live in. For now, let us refer to the feedbacks from 29 international graduate students from Tier One of 2017 trip.

**愛德溫 Gamborino Castaneda Edwinn**

**墨西哥 (Mexico)**

**臺灣大學 NTU 電機工程學系 碩士生**

The enterprise visit gives me a deeper understanding about the current Taiwanese industry. The industry visit was interesting and it was informative to get to know the companies. For future visit, my suggestion is that companies could invite employees to share their working experiences and daily routines. They could also provide information on what kind of job opportunities and careers are available in their respective companies. I also liked the investment information session. I believe that few people, including myself, have considered this

opportunity. While in recent years it has become much more common for people to start their own business thanks to crowdsourcing platforms and startup incubators, it is well known that a startup is a very taxing, high-risk endeavor that few people are willing to take. Nonetheless, it is good to know that the Taiwanese government facilitates support for those that are willing to try. It would be better to have more information about how they can support us in moving to Taiwan and facilitate the process of getting a working visa. Personally, given the right conditions, and with a good idea, I might try in the future. Overall, I think it was a good experience, getting to know other foreign students, and sharing experiences and contacts which are both important to our professional development.

**鄭成利 Thanawat Tachasomboonsuk**

**泰國 (Thailand)**

**元智大學 YZU 工業工程與管理學系 碩士生**

Originally, when I applied for the CTCI camp, I had anticipated to visit Asus Company as I wanted to see their innovation and technology. Due to schedule change by the camp, I was disappointed. However, through the visit, my disappointment was replaced by the new discovery and new experience from visiting companies including TECO, Shihlin Electronic, Fortune Electric, Hon Chuan, and Fair Friend. These companies gave me a new perspective about Taiwanese company because all of them do great things with innovation and high technology. Fair Friend Group really surprised me the most while I was watching their presentation. The company has already taken over more than 100 machinery companies around the world. It is simply a big company with very high revenues. This changes my understanding of what big and well-known companies in Taiwan should be. Moreover, this camp gives me warm welcome and suggestions. The camp gives foreign students more opportunities to work in Taiwan. According to these visited companies, they have high potential to expand in global market, and are able to offer jobs to us who are non-Taiwanese citizens. My experience of finding jobs in Taiwan was difficult, because the job hunting websites are in Mandarin, and many companies do not need foreigners. This





camp suggests another way to find jobs in Taiwan and also helps us to explore international Taiwanese companies that I did not know before. I would like to thank CTCI Foundation because of it.

### 史茗艾 Miriam Aida Sibrian Bueso

宏都拉斯 (Honduras)

元智大學 YZU 管院博士生

I'm very grateful for this opportunity provided by CTCI Foundation. Until a few days ago, Taiwanese companies were a mystery to me, I have always wanted to know details such as how to get a job here, what industries are looking for foreigners, and how is the working environment, and what are the requirements for foreigners? This visit gave me a better perspective on how to get a job in Taiwan as a foreigner. At first, I thought finding a job in Taiwan as a foreigner will be a difficult task. However, after participating in this visit, I feel more confident that I can find a job here. With this trip I gained a better perspective on Taiwanese industries and their working culture. I was surprised that in every company, there is always a breast feeding room. This shows they care about their female workers and provide a pleasant working environment for their employees. Also, it surprised me that most of the companies are very stable, growing at a fast pace as highly qualified companies with ISO 9001 and ISO 50001 standards. A suggestion for the companies is that during next visit, they can show the number of international employees working for them in the presentation. It was very inspiring to see a foreigner presenting products on behalf of Fair Friend Enterprise; I think this can be a good example for future visits. Another suggestion is for companies to include presentation on the kinds of incentives employees receive, rate and numbers of employee satisfaction, job openings, and contact information of HR manager.

### 阮英俊 Nguyen Anh Tuan 越南 (Vietnam)

中興大學 NCHU 應用數學系 博士生

During the three-day trip, I learnt about Taiwan's representative companies and their products introduction. These included: TECO Electric & Machinery Co., Ltd., Shihlin Electric &

Engineering Co., Ltd., Fortune Electric Co., Ltd., Taiwan Hon Chuan Enterprise Co., Ltd., and Fair Friend Enterprise Co., Ltd. Throughout the visits, I realized that the demand of recruiting international students for Taiwan labor market is huge and I have many opportunities to find a job here. Coincidentally, in the past, I had already worked for CTCI Corporation (中鼎工程) in Vietnam as a piping engineer. One of the most important targets of this trip is to find jobs for international students. My suggestion is that, during the meeting with companies, it would be much better if the company staff could show more job openings which are available as well as the related qualifications for application. Thank you so much for the trip and support from the staffs. I hope to find a job soon and even get opportunity to work for the CTCI Corporation again.

### 張琮鴻 Hung, Do Cong 越南 (Vietnam)

中正大學 NCCU 電機工程學系 碩士生

I want to thank CTCI for providing three-day enterprise visits, which makes me feel so refreshed and satisfied. The trip not only brings me many memorable experiences, but also helps me to learn of Taiwan's working environment and job opportunities. We had visited five companies in total and the most interesting companies to me are TECO, FFE and THC respectively. These companies are all closely related to my study field and they are all looking for a cooperative business in Vietnam. TECO is famous for motor making, and now they are trying to make motor becoming smarter by applying AI or IoT within. FFE is well-known as precision tool making company which is so close to my former major of Automation. THC surprised me with the up-to-date-automation manufacturing line. The other three companies of Shihlin, Fortune, and ITSC also enriched my experience and understanding about Taiwanese enterprise. Even though Shihlin and Fortune specialized in transformers maker, but they target different markets. ITSC interested me with their point-based salary payment and job listing website. After the trip, I try to contact two companies for future job opportunities and I hope I could become one of the company members in the future. The trip



also gives me a chance to meet new friends from the world. We shared stories with each other, and it is interesting to get to know various perspectives from friends with different personalities. I believe that we will have a positive network in the future.

**桑德揚 Rajendran Soundararajan 印度 (India)**  
**臺灣大學 NTU 光電工程學研究所 博士生**

It was my first enterprise visit in Taiwan. It is exciting to see such a small country can have a huge manufacturing industry. I did not know TECO is the largest manufacturer of motors and covers diversified fields of manufacturing on top of home appliances. As a physicist, I was glad to see the making of transformers from Shihlin and Fortune Electric Corporations. The technical staff explained information on transformers and its making very well. The visit to InvesTaiwan Service Center was important and much appreciated. As a foreigner, we should know important guidelines about working and starting business in Taiwan. For the visit to Taiwan Hon Chuan, a packaging manufacturing company, I was surprised that only few technicians were there for beverage packaging. Utilizing advanced machines and equipment, it was completely automated from start to finish. The Fair Friend Group was my favorite company. This company is the world's third largest machine tool manufacturer and has branches all over the world. Their monitoring of units and processes are really advanced given the use of current VR technology. If I get a chance, I would like to work in this industry to improve my skills. The visit to the earthquake museum was very useful to learn about earthquakes, building constructions in Taiwan, and safety guidelines. No one can stop natural disasters, but we can always work on precautions to ensure safety. Overall, it was a wonderful experience. We not only get to see different processes and machineries running live projects, but also learn about internships and job opportunities here.

**SINGH, Haobijam B. K. 印度 (India)**  
**台北科技大學 NTUT 電資學院外國學生專班 博士**

The enterprise visit sponsored by CTCI

Foundation provides a meaningful platform to explore new and efficient technologies, socialize with people with diversified cultures and ethnicities, and explore new possibilities for job seeking students. Every company discussed what they value and shared discoveries and technological applications of new craft, tools, and products. The one-on-one talk with experienced experts also helps students to understand various requirements for the depth of cooperation required beyond general school education. The special interest group session allows students to swap implementation tips or techniques and listen to descriptions of both proper and improper ways. Overall, it provides an overview of the state-of-the-art in a given area and shares important research advances in a field of special interest to participants. The best part of this journey is that every company shares their management practices amongst diverse Taiwanese technological companies, strategies on how to expand markets in new regions. They also provide job opportunities to foreign talents. This enterprise tour is of high quality and equally beneficial to each individual student. A suggestion for future visit is perhaps adding software companies on top of current IT and electric companies. This trip revealed significant information in our daily life which we never give importance to. Last but not least, my special thanks go out to CTCI Foundation for providing such a wonderful enterprise tour.

**Osman Ahmed Zelekew 衣索比亞 (Ethiopia)**  
**台灣科技大學 NTUST 材料科學與工程系 博士生**

I think I was one of the luckiest students to get the opportunity to visit world-leading companies in Taiwan. As a PhD student for the last three years, I mainly focused on my lab work throughout these years. Because of this reason, even though Taiwan is a developed country now, I still did not know much about these companies. The trip was amazing and showed many job opportunities in Taiwan. As well, CTCI also helps me to open my eyes in the search for other job opportunities. It was one of the most fantastic trips I ever had in my life, I learnt a lot, and feel inspired and motivated. I appreciate support from other participants. Please continue this visiting program for future students.





**阿芭特 Alfonsina Abat 印尼 (Indonesia)**  
**中央大學 NCU 化工與材料工程學系 碩士生**

It was my pleasure to attend this amazing enterprise visit activity by CTCI. By joining this program, I have learned many things. There are abundant opportunities of expatriate works with many of Taiwan's big companies. The contribution of foreigners helps to develop the economy. As well, there are guidelines to be followed to fulfill some requirements to become a professional worker here. The enterprise tour allowed us to get first-hand experience to see the real working atmosphere in the companies of TECO, Shihlin, Fortune, Hon Chuan, and Fair Friend Enterprise. I met many great international talents in Taiwan, as they are not only smart in their field of studies, but also speak English fluently as well as Mandarin. I just realized the importance of mastering Mandarin language can be beneficial for my future career. Therefore, it motivated me to improve my Mandarin proficiency. Originally, I had planned to go back to my country after finishing study at National Central University. But, through the visit, I realized many new opportunities were given to me, including working in Taiwan. I now have reasons to strengthen my ability after joining this event now. Thanks to CTCI Foundation for the kind and friendly guidance. Not only did I learn many things, but I also enjoyed this trip so much. CTCI Foundation is great at sponsoring this activity, and I hope this activity can be well known by all international students in Taiwan.

**Fica Aida N. Aini 印尼 (Indonesia)**  
**長庚大學 CGU 機械工程學系 碩士生**

During the July trip, we visited five big companies in Taiwan. TECO is one of the top electric motors manufacturers in Taiwan which specializes in manufacturing electric motors for more than 52 years. Taiwan has a good prospect in manufacturing industry with Shihlin Electric and Fortune Electric, known as two great manufacturers of electric and power transformers. Hon Chuan produces packaging for beverage products, including plastic bottles, bottle caps, and labels.

Some of the major customers include Coca Cola, Pepsi, Uni-President and so on. Fair Friend Group (FFG) is Taiwan's largest machine tool maker. And we also visit one governmental sector, InvesTaiwan Service Center (ITSC), which offers free service for foreigners who want to work or invest in Taiwan. It is such a wonderful trip that we get to learn about Taiwan's companies growing from scratch to the top of where they are now. As a foreigner student in Taiwan, I am interested in joining one of these companies when they offer vacancies matching my personal abilities. My suggestion for companies is to include more information about the job openings since the main purpose is to help Taiwan's companies recruit international talents.

**雷城 Lei Jian 中國 (China)**  
**清華大學 NTHU 化學工程學系 博士生**

很高興能參加這次中技社舉辦的活動，與來自 14 國 15 校的老師同學一起參訪企業、遊覽臺灣的美麗風景。首先，感謝中技社盡心盡力的安排行程與照顧每位學員，讓來自不同國家的同學們的食住行都感到舒適，也盡最大可能尊重每個人的飲食風俗。其次，我們參觀了 5 家公司：東元電機、士林電機、華城電機、宏全國際和友嘉集團，每一家公司都很熱心的接待我們，講解公司的發展史、主要產品及核心技術等。印象最深刻的莫過於參訪生產工作間，學習行業專業相關知識，也瞭解未來發展趨勢，豐富了自己的知識。非常感謝每家公司專業人員，在酷暑和嘈雜的廠房裡耐心的講解及一一解答問題。最後，感謝同行的同學，彼此尊重對方的習慣，愉快的進行交流，觀念碰撞，讓我獲益甚多。這次的活動非常成功，希望之後會陸續舉辦這樣具有意義的活動，促成更深廣的交流！

**森亞博 Kostadinov Yavor Asenov 奧地利 (Austria)**  
**淡江大學 TU 國際事務與戰略研究 博士生**

The three-day CTCI Foundation trip in July 2017 has been an enriching experience. I have learnt much about manufacturing business in the energy sector in Taiwan. Shihlin Electric impressed me much with their warm reception and presentation. Another company, Hon Chuan, was impressive as well. The Hon Chuan's HR presenter especially provided concrete job





vacancies. My personal suggestion is that, the selection of companies could be more polarized, so as to cover wider variety of industries. I was a bit disappointed that this visit did not include notebook makers because Taiwanese notebook producers are internationalized and hold majority stake in the global market. Overall, the trip was interesting, enriching, and positive. I would strongly recommend CTCI Foundation to my students in the future. Please accept my sincere gratitude!

**Mansour Jawida 巴勒斯坦 (Palestinian Territories)**  
交通大學 NCTU 人文社會科學 碩士生

Taiwanese enterprise trip as sponsored by CTCI is a unique experience to me in different aspects. First of all, I would not be given such chance to get to know the companies that we visited without this trip. I admire all the hard work I have seen from all of these companies. As a person coming from developing country, this is really an eye-opening experience to see what the future could be like by working step by step through people's commitment. Secondly, I learned presentation skills from the representatives at those companies, they are professionals in that they used trend notions in management and marketing. As well, the 921 Earthquake Museum of Taiwan is very informative and I learnt a lot about this tragic disaster. My thesis was about museum development and I am interested to see good examples and lessons that I can share with colleagues and this one was very helpful. Another amazing thing about this trip is meeting lovable people from different countries and forming new friendships. I truly wish to come back as an employee in the future.

**Ejigu Assamen Ayalew 衣索比亞 (Ethiopia)**  
台灣科技大學 NTUST 光電工程研究所 博士生

I would like to thank CTCI Foundation, and the organizers and those who were managing the visit from beginning to the end for their fantastic well-organized and kind treatment. The impact and important learning from the visit are summarized below. Social interaction : During the visits, I communicated with many participants as a way to

learn new experiences from new friends. Learning about Taiwanese enterprises : After the visit, I learnt that these Taiwanese companies are great in quality product and worldwide market. I also understood that strong motivation, passions, teamwork and cooperation are typical characteristics of Taiwanese companies. The information learning from TECO, FFG, THC are very impressive. An important note is that, I decided to work in Taiwan after my gradation because I believe Taiwan is the right place where you can find co-existence of peace, passion, hard work, and science in business practice. Science and technology : I think that science and technology of Taiwan should be a role model for other countries, especially for developing countries like my country. All high quality products in Taiwan indicate that Taiwan is using the modern science and technology properly. I believe the people of Taiwan have a special contribution to the world. I love Taiwan and I will tell people that Taiwan is a lovely country wherever I travel to. To sum up, the 2017 CTCI enterprise visit was successful and it changes my mentality deeply.

**Sathesh Tamilarasan 印度 (India)**  
台北科技大學 NTUT 製造科技研究所 碩士生

To begin with, I would like to thank CTCI Foundation so much for providing this opportunity. As the Indian proverb says, "cultivating good thoughts into someone's mind is not only for their growth, but also for all over the world", this enterprise visit helps us to see a different domain. Aside from learning culture of Taiwan, we also met new friends to form good relationship from the trip. As well, we got to see new approaches for technological breakthrough in these companies. The visit has provided five different kinds of company and one governmental organization, productions, and infrastructures. We have learned new technologies with new perspective. This attracted everyone to seek employment in Taiwan, as everyone wants to work with a well-respected organization. From this trip, I personally liked and wanted to work for companies such as TECO and FFG. I appreciate the hospitality as well as enterprise visit opportunity from CTCI.



**Namkhaidorj Galkhuu 蒙古 (Mongolia)**  
**東華大學 NDHU 企業管理學系 碩士生**

My thanks go out to the CTCI Foundation and staff for organizing this 2017 enterprise visit. At first, I am eager to learn about how these leading companies operate in Taiwan, as well as how they run factories. Unlike pictures from textbooks, products in different industries are carefully designed, planned, and then manufactured through production stages as the end products. As I am still trying to connect my research to real business model, the 3-day enterprise visit is really inspiring as it gives me precise pictures to build up my own business in Taiwan, and motivates me to conduct my research more actively. My suggestion is that perhaps we could consider visiting two more companies on the third day. And it might help to include nano technology or biotech industries on the visit list, aside from manufacturing giants, since this might be quite interesting to participants. Other than that, information from InvesTaiwan is helpful and insightful.

**Girma, Wubshet Mekonnen 衣索比亞 (Ethiopia)**  
**台灣科技大學 NTUST 化學工程研究所 博士生**

The company visit provides opportunity for international graduate students studying in Taiwan universities, to develop practical experience and get first-hand information for running industry-based researches. It also helps to connect students to high-tech companies with recruitment needs for international talents. TECO's high standard technology with ISO 9001 and ISO 14001 certificates as well as energy efficiency certificates makes me want to have such TECO branches in my home country too. Shihlin Electric & Engineer Corporation manufactures electrical and power transformers, switch gear, controls and automotive electrical devices. Every year, it goes through design re-development and market enhancement for continuous improvement. Fortune Electric makes products similar to those of Shihlin Corporation. THC Company specializes in packaging automation. As we have seen from the trip, it is going beyond labor-intensive stage and working to be environmental friendly. Fair Friend Enterprise Corporation is a wonderful company that

engages in machine tool, PCB, industry equipment, and green energy businesses. Generally speaking, the trip was successful with wonderful memories. Industrial visit activity created possibility for having a job in Taiwan, which I am looking forward to after graduation. My personal suggestion is perhaps we could increase the number of participants in the future. Since many students want to join the visit and work in Taiwan, but do not have such opportunity yet.

**柯昀君 Killian Brittany 美國 (United States)**  
**臺灣大學 NTU 公共衛生學系 碩士生**

Thanks much to the CTCI Foundation and staff for organizing this trip and providing a wonderful experience for foreign students! In my opinion, it is already a good thing that foundations such as CTCI are proactive in organizing these trips and encouraging foreign students to stay in Taiwan after graduation. Many foreigners that I have met in Taiwan are under the impression that Taiwan, in general, does not provide a welcoming work environment for foreigners. Trip such as this shows that there are government entities that are working to make it more welcoming for international talents. Because none of the companies were related to my field of study, I did not get the chance to make work connections on this trip. I would recommend either making sure the trip includes a variety of companies, or targeting the trips for specific majors (i.e. engineering, marketing, sales, business). For example, the first trip could be for the aforementioned majors, and the second trip could be for other students from different degrees and interests.

**To Thanh Thu 越南 (Vietnam)**  
**虎尾科技大學 NFU 工業管理系 碩士生**

Thank you so much for providing enterprise visit activity. It was interesting and I felt excited to meet friends from different countries, cultures, and traditions. While I have studied about Industry 4.0 in university, I acquired new knowledge when I could see factory operation up close and personal. Taiwan is known for its manufacturing industry. Through this visit, I realized Taiwan is also quite developed with high tech, Industry 4.0, and green industries.





### Vinothkumar Jeganathan 印度 (India) 台灣科技大學 NTUST 電子工程系 博士生

The three day trip was a great experience for me to learn what job opportunities are available in Taiwan, and the criteria for foreigners to be recruited by these companies. I was pleased to learn about options which are available to international students. As well, I got to meet people coming from different countries and cultures. Unlike movies, the trip gave me the real time exposure at factory. It is my first time experiencing advanced technology of Industry 4.0 with virtual reality. I am much impressed by Shihlin Electrics, Fair Friend Group and THC. I learned a lot of practical ideas about transformer manufacturing and other interesting things. The session at ITSC with the government agents helped to clarify many previous doubts we had about VISA process, permit, and other formalities. I was worried about my career before attending the visit, but now I am feeling somewhat relaxed that a lot of options are available for international students. It would be nice to learn which students benefitted from the enterprise visit. I am very thankful to the CTCI Foundation for the wonderful arrangement. Please kindly continue this type of enterprise visit activity for international students.

### 游翰思 Yohanes Hutabalian 印尼 (Indonesia) 清華大學 NTHU 化學工程系 碩士生

The CTCI enterprise visit of 2017 helps me to know more about the prospect of working and establishing career in Taiwan. We have visited five companies, most of them play important role in industrial productions. For example, TECO's motor products such as air conditioners and other kinds of motors are mostly used in Taiwan. Moreover, these companies' products are exported to places around the world. Some of their branches and sales offices are not only in Taiwan, but also in other countries. During the factory tour, we were guided and explained about how products were designed and produced from beginning to the end with a chance for up close and personal observation during the process. All company staffs welcomed us to join their company as foreigners who would be graduating from universities in Taiwan. Although

I was not interested in a few of the companies, the visit itself was still a valuable experience in my life. All of these companies care about employees' welfare, environmental friendliness, and efficient management. After my graduation in 2018, I will try to find a job in Taiwan as my first career. There is also a good possibility that perhaps I can still work with one of those companies' subsidiary in my country of Indonesia. The third day sightseeing arrangement is also one of my favorite parts about this trip. In these three days, I met new friends who are very talented and I will keep in touch with them.

### 劉媛 中國 (China) 清華大學 NTHU 材料科學工程學系 碩士生

感謝中技社規劃安排這次境外生企業參訪活動，讓我們有機會了解一些台灣的國際企業，了解沒有機會接觸到的領域，收獲新經驗及新知識，結交新朋友，品嚐當地特色料理，參觀新打卡景點，在中技社貼心照顧下，讓我們有三天難忘的旅程。這次參訪特別安排了三家不同的電機廠參觀，通過連續參觀兩家生產變壓器的電機廠，使我對變壓器的製備和構造有了更進一步的了解，從課本中的理論圖走出對應實際的設備，一開始還覺得有些抽象，但在每家企業的工作人員詳細介紹後慢慢地開始理解了機器每個部分的功能和作用。除了電機廠，我們還參觀了宏全公司自動化飲料的塑膠包裝過程，和友嘉集團的機械零件產品，都受益匪淺。最後一天下午的大雨是旅程的小遺憾，但不會影響我對整體行程的正向評價。真心推薦中技社企業參訪活動，真的很棒！

### Kefyalew Dagnew ADDISU 衣索比亞 (Ethiopia) 台灣科技大學 NTUST 應用科技研究所 博士生

I enjoyed the visit very much and appreciated the opportunity and hospitality from CTCI. The enterprises and dedication from the CTCI team are impressive, and this makes me think the Taiwanese society is special. My comment for future visit is that, while all companies are great for this trip, as I am studying in field of Biotechnology, it might be helpful to add some biotech companies. As I heard, the government of Taiwan places a great effort on biotech and biomedical industries. I will look forward to hearing future information or update from CTCI. I really appreciated the opportunity and thank you for



the hospitality and support for the foreign students.

### 吳劍遠 中國 (China)

#### 清華大學 NTHU 材料科學工程學系 博士生

本次企業參訪中對宏全的 in-house 創新商業模式帶來的思維衝擊和印象最為深刻，與理工科領域常接觸到的技術為王的思路不同，宏全以外延思維連結上下游，化繁為簡，減少對接環節成本，創造了雙贏，在密切合作關係的基礎上，進一步拓展了自身的業務版圖。在技術以外還有更廣闊的世界，這是宏全給我最大的啟示。第三天的觀光，徜徉在彩虹眷村的美好中，我想到的是，你的價值具備不可替代性，這個世界將為你保留一片天地。於我，頭一次如此密集且連續地跟外國朋友接觸，英文口說有打通任督二脈之感。返校歸舍，我的印度室友聽完我的見聞，扼腕於當時沒有留意到中技社的活動資訊，建議在經費允許的狀況下，可適當投入諸如 FB 等新媒介平臺的經營，一者提升這項活動在青年族群中的傳播效率，二者可在平臺上即時發布活動照片等，令貴社的公益形象更為鮮活親切。三日一別，餘韻未了，好懷念跟大家在一起的三天。

### Syed Ahmad Raza 巴基斯坦 (Pakistan)

#### 台灣科技大學 NTUST 機械工程學系 博士生

The company personnel of TECO were friendly. Their presentation was very helpful in providing a comprehensive overview of the company operations. At InvesTaiwan Service Center, the presentation given by the hosts was informative and helpful to foreigners. Besides giving information for entrepreneurs looking to invest in Taiwan, the center could also try to include information on how to go about initiating startup and fund-raising in Taiwan. At Shihlin Electric, the representatives of the company gave a good explanation of the ongoing manufacturing processes and answered technical queries proficiently. The representative from Fortune Electric gave a very good presentation and the visit through the transformer manufacturing plant was a very useful learning experience. At Taiwan Hon Chuan Enterprise, the presentation was useful in providing us with a good idea of company operations. At Fair Friend Enterprise, the presentation was professional, impressive and

gave detail information regarding company's vast operations. Their virtual factory setup, real-time monitoring of facilities abroad and fully connected online management system were very remarkable. To be a mechanical engineer, there were a lot to learn in the plant. For students looking for research-based jobs, the corporations could consider including an introduction to their R&D projects. Having a visit to R&D facility would help us gain an understanding of the research environment in the industry. This trip has given me a valuable glimpse into Taiwanese industry that could potentially affect my future career direction.

### 林方馨 Lim Fang Shin 馬來西亞 (Malaysia)

#### 臺灣師範大學 NTNU 數學研究所 碩士生

The enterprise visit was great. The companies on the list are big and famous. The company HR also introduced these corporations in a clear and easy way to all foreign participants. The itinerary for last day was awesome. Visiting earthquake museum was an interesting activity and it really opened my eyes to a new kind of domain as I acquired new-found knowledge about earthquakes. As well, the rainbow village is as beautiful as a memorable place for visitors. A personal thought is that, perhaps CTCI Foundation can provide some snacks such as biscuits or breads for the first day when student group gathers together. I will recommend this activity to all my friends and juniors, to take part for next visit, thanks!

### 習顯恬 Siti Sulikhah 印尼 (Indonesia)

#### 台灣科技大學 NTUST 電子工程學系 碩士生

“The product that wins is the one that bridges customers to the future, not the one that requires a giant leap” (Aaron Levie, co-founder of Box). From the enterprise visit, we learn about “real business” and engineering management through observation of operation of the company and plant. It is a practical opportunity to learn about factory production and work-related opportunities and information. One of the leading manufacturers of power-related products, Fortune Electric Corporation, is committed to connect worker and





industry 4.0, as well as carefully balance operations, profitability and sustainable development. On the other hand, Shihlin Electric has successfully signed a long-term exclusive contract with leading American manufacturers to represent their interests in vehicle electrical equipment. In addition, it is also an important supplier of Taipei 101. Both of these are collaborated under guidance of Taiwan Power Company (TPC). As well, Fair Friend Group (FFG) is consisted of CNC machine tool factory with Green Energy development. This company has created intelligent machine tools with concepts of “new”, “renewable”, and “energy”. To provide the best products and services, TECO Corporation is on the cutting edge of renewable energy technology to help change the world. The InvesTaiwan Service Center (ITSC) offers an integrated window to provide more business-friendly services and attract international firms to invest in Taiwan. This system is the result of coordination mechanism and joint effort by various county governments.

**岑宛珊 Silvia Jocunda 印尼 (Indonesia)**  
**成功大學 NCKU 建築系 碩士生**

TECO Electric and Machinery impresses me much as it is a big manufacturer of all kinds of motors from big sized industrial machineries to small sized electrical appliances. InvesTaiwan Service Center : It provides a very useful platform as matchmaker between job seekers and companies. Shihlin Electric & Engineer : The factory visit gives me a new perspective for Taiwanese manufacturing factories. The one that impresses me the most is the size of transformers. It could be produced with large scale used for wind turbine. The company does not always depend on machines, as it still needs workers to do some parts of the work. Fortune Electric is my favorite company, since the factory is large, clean, and well-organized which specialized in production of big transformers. This is my first time to see large transformers, and learn that in order to ship to overseas customers, the biggest transformers must be sent in parts. However, for the transformer's core, it must be well-sealed with waterproof materials and it is impossible to dismantle and send in parts. The visit gives me

a new perspective on how transformer is being produced in a professional and great factory like this in Taiwan. Taiwan Hon Chuan Enterprise : When I see this company's production process, it is high tech and specialized in mass production of different kinds of beverages in bottles. Fair Friend Enterprise has many kinds of production uses for machinery and transportation. It also applies high tech system to organize and run metal production such as transformers. It is truly an unforgettable enterprise visit activity I ever participated.

**Eka Adi Prasetyo J.P. 印尼 (Indonesia)**  
**台灣科技大學 NTUST 電子工程學系 博士生**

TECO is a great and the largest manufacturer of heavy power in Taiwan. It manufactures high performance motors as main products and has a global market share in more than 30 countries. InvesTaiwan Service Center, a government agency, helps companies in needs of international talents to recruit and also provide consulting services. ITSC representative demonstrated the online registration procedure and explained the steps to apply for a working permit. Shihlin Electric focuses on manufacturing power-related products, such as vehicle electric equipment, heavy power products, industrial products, and automation equipment. Fortune Electric is a leading domestic power transformer manufactures; Hon Chuan manufactures integrated beverage packaging; FFG is the third largest CNC machine tool maker with three major divisions of business, such as machine tool, industry equipment, and green energy division. My favorite company is FFG, because of the brilliant strategy by CEO Jimmy Chu to merge many companies in order to expand production scales and market shares in the world. Specifically, FFG implements high technology on their products as complicated as airplane wings and components of High Speed Rail. And for the last day, we travelled to the Rainbow Village located in Taichung. It is a state-of-art, rainbow grandpa paints on the house wall and the street with colorful cute pictures from flowers, trees, birds to a variety of other animals. I hope CTCI Foundation will continue organizing meaningful and enjoyable trip like this.



▲ 能源技術發展中心 王新銘主任 · 劉致峻副工程師

近年面臨核四封存、既有核電廠屆齡除役、火力電廠設廠困難、再生能源無法穩定供電、國際能源價格波動與溫室氣體排放等內外挑戰。本社本著公益法人的立場，鑒於各界對於國內能源情勢之關心，嘗試建構一套能夠對於能源供應、需求及基礎設施情況進行綜合評估的指標系統，做為政府檢討能源相關政策的參考依據，協助國家達成能源供需穩定、經濟持續活絡、社會永續發展的願景。

此項議題由國立中央大學管理講座教授梁啟源博士擔任主持人，並由本社研究成員與財團法人中華經濟研究院的專家學者共組團隊進行「共同研究」。以世界能源理事會 (World Energy Council, 以下簡稱 WEC) 的「能源供應安全之風險與脆弱度的衡量 (Security of Energy Supply Indicators for Measuring Vulnerability and Risk)<sup>1</sup>」作為基礎架構，建構一套考量我國能源經濟情況特性的本土化能源安全脆弱度。

本議題自去 (105) 年度初步完成脆弱度的試編工作，而今 (106) 年度更強化此指標對於過往重大政治、經濟、能源情勢變化的捕捉能力，並於 8 月 10 日召開一場「我國能源安全指標研討會」<sup>2</sup>，會中除了邀請財團法人台灣經濟研究院、行政院原子能委員會核能研究所等國內重要能源政策智庫分別發表研究成果之外，另以圓桌論壇之方式，邀集國內產官學研專家分析目前國內能源現況及產業需求，並提出政府能源政策走向之建言。以下將簡述本團隊所建構之台灣能源安全脆弱度的研究成果，與讀者分享。

## 一、WEC「能源供應安全之風險與脆弱度」簡介

國際能源署 (International Energy Agency) 定義能源安全 (Energy Security) 為「在可負擔的價格下能夠不間斷地取得能源」，且能源安全包含許多面向。長期下之能源安全主要在於

伴隨經濟發展與永續環境所需，及時增加能源供給，而短期內之能源安全則著重於能源系統在供需平衡中迅速應對突發性變化的能力。世界經濟論壇 (World Economic Forum) 所定義的能源安全，則是指「在可承受的價格之下，能有可靠、穩定和可持續的能源供應，並透過全球合作來有效地實現」。

而 WEC 自 2008 年起與歐盟合作，進行歐盟成員國能源風險的衡量，其基礎架構參考 Frondel 等人 (2009)<sup>3</sup> 之方法學概念來衡量能源風險，特點包括：考量一國各類燃料供給中自產的貢獻、進口份額及燃料出口國之供應中斷機率，即著重於相對稀少性；其重點在於量化長期能源供給風險，數值反應潛在的化石燃料進口損失，換言之，此指標可被歸類為資源脆弱度或實體可取得性的指標。

然而，Frondel 等人 (2009) 之方法學，僅著重供給面的變化，並未能充分考量需求面的情況，故有視能源需求為外生給定的限制，且忽略了基礎設施在整體能源系統的重要性。因此，WEC (2010) 在此方法學的基礎上，將能源風險的衡量及脆弱度擴展至三個層面：第一層為初級能源供應風險，考量不同能源的進口依存度、自產能源占初級能源供應比重、能源多樣性和能源進口來源國的供給中斷風險；第二層則考量電力和天然氣等基礎建設的品質和可靠度；第三層則納入消費端對能源風險影響，例如消費端可透過增加能源使用效率，促使能源使用與經濟成長脫勾等，可減緩能源危機帶來的潛在影響。

依據 WEC (2010) 的架構和概念，初級能源供應風險主要衡量煤、油、天然氣、鈾及其他初級能源之進口概況，以及各類能源之進口分散程度和各進口來源國之政治風險程度，經由標準化加總為初級能源供應脆弱度；其次，在天然氣基礎設施中，主要考量第一層當中之天然氣供給風險，以及國內天然氣儲存能力，藉由兩項數值來衡量天然氣基礎設施風險變



化。再者，就電力基礎設施風險而言，主要以電力生產結構風險、與週邊國家電網連接度、儲備電容能力（即備用容量率）和需求波動等，作為呈現一國電力基礎設施風險程度；然後經由標準化加總為基礎設施脆弱度。此外，就最終能源消費風險方面，則以能源消費配比、能源效率與能源支出，然後一樣透過標準化加總出該國最終能源消費脆弱度。

簡而言之，WEC 將國家能源安全依能源供應、能源基礎設施和最終能源消費等面向進行系統性分析，可深入解析一國能源風險更為細緻的變化成因，且其指標所需資料亦能符合公開透明、具可信度、具延續性、完整性等相關原則。本研究考量台灣為獨立電網，更需重視基礎設施端之風險變化，故本研究選擇了 WEC 之能源風險及脆弱度作為分析我國能源安全程度之架構，並在此基礎上進行本土化的試編工作。

## 二、「台灣能源經濟脆弱度」本土化方法學

台灣能源經濟脆弱度係由初級能源供應脆弱度（PEV）、基礎設施脆弱度（IV）和最終能源消費脆弱度（EEV）所組成。本研究考量我國電力系統屬於獨立電網，並未對外連接的特性，進一步調整基礎設施風險衡量項目，調整後之架構如圖 1 所述，並說明方法學如後。

### （一）初級能源供應面

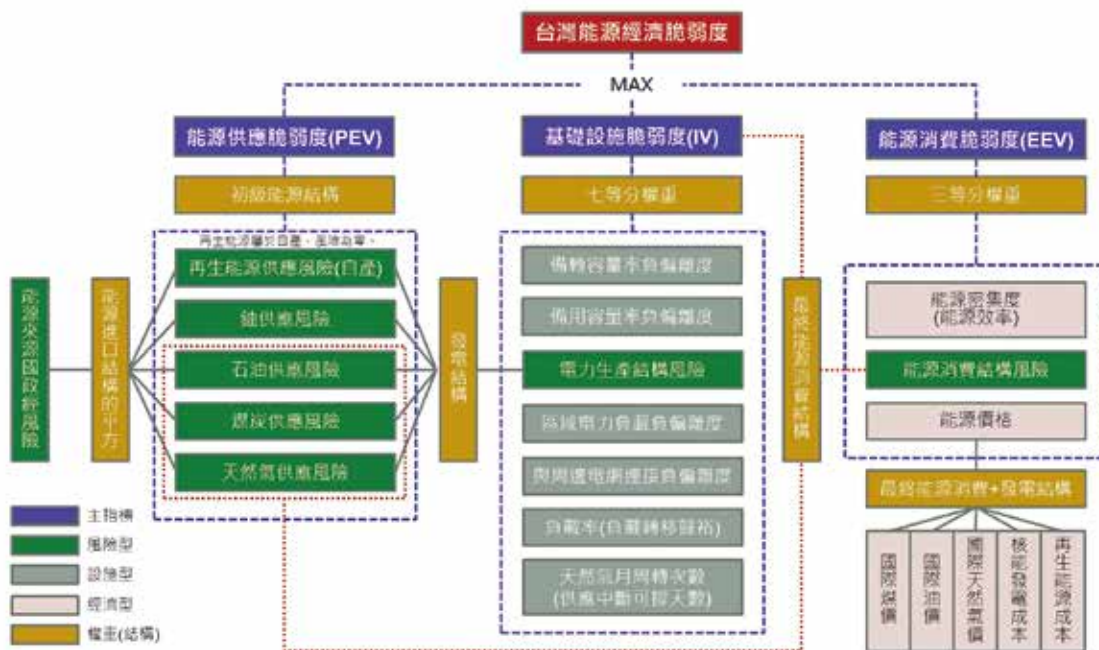
計算初級能源供應脆弱度的步驟有兩個階段，首先計算特定初級能源別的供應風險（ $PEV_i$ ），再於第二階段依據初級能源占比加權計算成總初級能源供應的脆弱度（PEV），指標意涵與公式分述如下：

#### 1. i 類初級能源供應脆弱度（ $PEV_i$ ）

$$PEV_i = x_i^T \cdot R \cdot x_i = x_{id}^2 \cdot r_d + \sum_{j=1}^J x_{ij}^2 \cdot r_j$$

其中， $x_i = (x_{id}, x_{i1}, \dots, x_{ij}, \dots, x_{iJ})$  表示一國能源進口占比之矩陣；其中  $x_{ij}$  表示自  $j$  國進口  $i$  類能源占本國  $i$  類能源總供應占比； $x_{id}$  代表  $i$  類能源於國內自產之比率。 $R$  為能源出口國政經穩定度的風險矩陣； $r_j$  即能源由來源地  $j$  供應之風險指標，而  $r_d$  為自產能源之供應風險，原則上以 0 計算。各類初級能源的項目則包括了煤、石油、天然氣、鈾及再生能源（含其他）等初級能源。另外，本指標所引用的各進口來源國的政經風險，係根據 OECD 所建構的政經風險指數（OECD Political Risk）每半年定期發布的數據；並考量各進口能源來源國的集中或分散情形。

若某一類能源過於集中自少數國家進口時，顯示該類能源的進口來源不夠多元化，容易產生較高風險，假使各進口來源國的政經風險又偏高，則對一國之該類能源初級供給風險更為嚴峻。反之，假使進口來源國的政經風險較低，則即使進口來源雖屬集中，但因進口來



資料來源：本研究繪製。

圖 1 調整後之本土化能源脆弱度衡量細部架構圖

源國家的風險低，對一國之該類能源初級供給風險影響相對較小。綜言之，在衡量某一類能源之初級供給風險時，須同時觀察進口來源國數目或分散程度，及各國之政經風險高低。

## 2. 初級能源供應脆弱度 (PEV)

$$PEV = w^T \cdot X^T \cdot R \cdot X = w^T \cdot \Pi^T$$

其中， $w = (w_1, \dots, w_i, \dots, w_l)$  表示各類初級能源供應占比向量，亦即  $w_1 + \dots + w_l = 1$ 。 $\Pi$  為各類能源供應脆弱度矩陣；本矩陣的對角線  $\pi_{ii}$  即為  $PEV_i$ ，故

$$\pi_{ii} = PEV_i = x_{id}^2 \cdot r_d + \sum_{j=1}^J x_{ij}^2 \cdot r_j \geq 0$$

值得注意的是，在原始 WEC 的架構之中，PEV 係從  $PEV_i$  以  $i$  類能源供應量占該國總能源供應「占比平方」為權數計算而得。然而，後述之基礎設施面的電力生產結構風險及最終能源消費面的最終能源消費結構風險所採用之權數，係以  $i$  類能源占該國總發電量「占比」，及  $i$  類能源占該國最終能源消費量「占比」，故出現不一致狀況。本研究經數次專家諮詢會後，決定採取一致的權數設計，以各類初級能源供應「占比」取代「占比平方」作為權數。

## (二) 基礎設施面

### 1. 備用容量率負偏離度

$$\lambda_1 \times \frac{|PRM_t - ORM|}{ORM} \times I(PR M_t > ORM) + \lambda_2 \times \frac{|PRM_t - ORM|}{ORM} \times I(PR M_t < ORM)$$

其中， $PRM_t$  (Percent Reserve Margin) 為備用容量率實績。ORM (Optimal Percent Reserve Margin) 為最適備用容量率，設為 15%。公式前項代表資源閒置，後項代表備用不足。 $\lambda_1$  及  $\lambda_2$  為權數，目前分別設為 0 與 1，亦即僅考慮電力供應可能不足的風險。

備用容量率衡量電力系統發電端供電可靠度。備用容量率如果低於最適值，則可靠度下降，甚至限電。故若負偏離度愈高，代表系統出現限電的可能性越高。

### 2. 備轉容量率負偏離度

$$\lambda_1 \times \frac{|POR_t - OOR|}{OOR} \times I(POR_t > OOR) + \lambda_2 \times \frac{|POR_t - OOR|}{OOR} \times I(POR_t < OOR)$$

其中， $POR_t$  (Percent Operating Reserve) 為備轉容量率實績。OOR (Optimal Percent Operating Reserve) 為最適備轉容量率，設為 10%。公式前項代表資源閒置，後項代表備用不足。 $\lambda_1$  及  $\lambda_2$  分別設為 0 與 1。

備轉容量率衡量每日電力系統的實際供電餘裕（扣除歲修、檢修及故障的機組裝置容量）。備轉容量率如果低於最適值，則可靠度下降。故若負偏離度愈高，代表系統出現限電的可能性越高。

### 3. 區域負載負偏離度

$$\sum_i \left[ \left( \lambda_1 \times \frac{|S_{it} - D_{it}|}{D_{it}} \times I(S_{it} > D_{it}) \right) + \left( \lambda_2 \times \frac{|S_{it} - D_{it}|}{D_{it}} \times I(S_{it} < D_{it}) \right) \right]$$

其中， $i=N, M, S$ 。公式前項代表供大於需，後項代表需大於供。 $\lambda_1$  及  $\lambda_2$  分別設為 0 與 1，即僅考慮區域間電力供應可能不足的風險。

我國電網分北、中、南三區，區域內應維持發電與用電相當為最佳，若區域內發電不足以供應用電需求時，須透過跨區輸電幹線輸送電力支援。故負偏離度愈高表示各區域內電力供需愈不均衡，區域間電力輸送壓力較高。

### 4. 與他國電網連接負偏離度

$$\lambda_1 \times \left| \frac{\text{與他國並聯容量}_t}{\text{本國裝置容量}_t} - \text{最適連接度} \right| \times I \left( \frac{\text{與他國並聯容量}_t}{\text{本國裝置容量}_t} > \text{最適連接度} \right) + \lambda_2 \times \left| \frac{\text{與他國並聯容量}_t}{\text{本國裝置容量}_t} - \text{最適連接度} \right| \times I \left( \frac{\text{與他國並聯容量}_t}{\text{本國裝置容量}_t} < \text{最適連接度} \right)$$

其中，最適連接度依據歐盟的建議設為 10%。 $\lambda_1$  及  $\lambda_2$  分別設為 0 與 1，亦即僅考慮我國與他國電網連接度低於歐盟建議最適值的風險。

我國的供電系統孤立，無法藉助鄰國輸電進行供需調節，故若負偏離度愈高表示電力系統自立求生的壓力越大。迄今我國與他國電網並聯度為 0，壓力最高，若未來我國電網能與他國連接，將可降低風險。

### 5. 負載率

$$\text{平均負載}_t / \text{尖峰負載}_t$$

其中，分子為特定時間內（日、月、年）平均每小時之輸出電力。例：全年發電量除以 8760 小時（一年小時數），分母則為特定時間內每小時輸出電力之最高值。

一般而言，負載率代表設備利用率，越高越好。但因為負載率具有極值（100%），若太過接近極值，代表所有機組都處於高運轉狀態，若電力需求突增，將容易導致跳電。另外，和主要國家比較，我國的負載率極高，代表未來再進行負載轉移的空間所剩無幾，故以此指標捕捉負載轉移空間餘裕降低的風險。



## 6. 天然氣月周轉次數

天然氣當季最大月用量 / 天然氣可儲存容量<sub>t</sub>

其中，分子為能源統計月報為當季天然氣月消費量最大值，分母則為全國天然氣接收站設計容量加總。

本指標表示天然氣最大儲存容量每月將用盡幾次。一般而言，周轉次數越高，存貨周轉率越高，從取得至消耗所經歷的天數越少，故也代表存貨管理效率越好。然而，由於液化天然氣載運船若在入港前後遇到颱風，須因安全因素遠離待命。引此，若天然氣進口來源中斷可撐天數小於3天，台灣即有可能因為颱風因素而斷氣。故以此月周轉次數捕捉天然氣進口來源中斷下可撐天數降低的風險。

## 7. 電力生產結構風險

$$\sum_i S_i \times PEV_i$$

電力生產結構風險受一國各類能源發電量占總發電量比重 ( $S_i$ ) 和各類發電燃料所對應之  $PEV_i$  而定。若發電組合集中於某一發電技術，且該發電技術所對應的能源供給風險偏高，將使電力生產結構風險較大，因此需藉由多元化和分散化方式來降低可能風險。

### (三) 最終能源消費面

#### 1. 能源價格

$$\sum_i S_{i,t} \times P_{i,t}$$

其中， $P_i$  為標準化後的煤、油、氣國際價格、再生能源（含水力）發電成本、核能發電成本（含核後端成本）。 $S_i$  為依據煤、油、氣與電力占最終能源消費結構比重，以及煤、油、氣、再生能源（含水力）、核能占發電結構比重，所計算的煤、油、氣、再生能源、核能的結構占比。

本指標捕捉能源進口成本、各類再生能源發電成本、核能發電成本（含核後端成本）的變化對於能源用戶使用能源的壓力增減幅度。

#### 2. 能源密集度

$$\text{最終能源消費量}_t / \text{實質國內生產毛額}_t$$

本指標表示我國的能源使用效率。數值越低代表能源使用效率越高，當能源使用越有效率時，可提高能源用戶因應能源價格上漲的能力，進而減少能源消費脆弱度。

#### 3. 最終能源消費結構脆弱度

$$EEV = \sum_i S_i \times EEV_i$$

其中， $EEV_i = (PEV_i, \text{基礎設施脆弱度})$  表示一國  $i$  類能源消費的來源風險程度，其中， $S_i$  為  $i$  類能源的最終消費占比。另外，電力部門對能源消費者的風險則以基礎設施脆弱度代表。

本指標表示能源用戶消費各類能源的來源風險程度。數值越高表示該國越集中消費特定能源，風險程度越高，若能源消費的品項越分散，則能源消費的來源風險越低。

### (四) 標準化與權重

為了解決不同指標具有不同單位與數值範圍的問題，WEC (2010) 原依據歐盟議會所建議的方法進行標準化，也就是指標  $q$  在地區  $c$  及時間  $t$  的標準化值 ( $I_{qc}^t$ )，等於該指標之原始值 ( $X_{qc}^t$ ) 減去其最小值之後，再除以其最大值與最小值的差（亦即全距）；但此標準化方式可能因新資料加入，改變原序列極值，產生全部回溯的情況，使結果不具一致性，加上部份數值經標準化後，可能其標準化值未能顯現原水準值代表之風險意涵。例如某一指標在特定時點下之原始數值為整個時間序列資料最小值時，則在標準化後將為 0，造成原始數值的風險因標準化後歸零的缺點，故本文將標準化方式加以修改，參見下式：

$$\begin{cases} I_{qt} = \{(X_{qt} - \text{Base}) / (\text{Top} - \text{Base})\} \times 100 & \text{if } X_{qt} \leq \text{Top} \\ I_{qt} = 1 & \text{if } X_{qt} > \text{Top} \end{cases}$$

其中， $\text{Top}$  為歷史最高點； $\text{Base}$  值則直接設為 0。指標標準化後進行加總時，則採由下往上的方式 (Bottom-Up)，由最底層的次指標開始計算，向上加總成主指標。此外，再視指標性質，分別採用能源進口占比平方、初級能源占比、發電占比、最終能源消費占比及固定等分權重的方式來設定權重。

## 三、編制結果

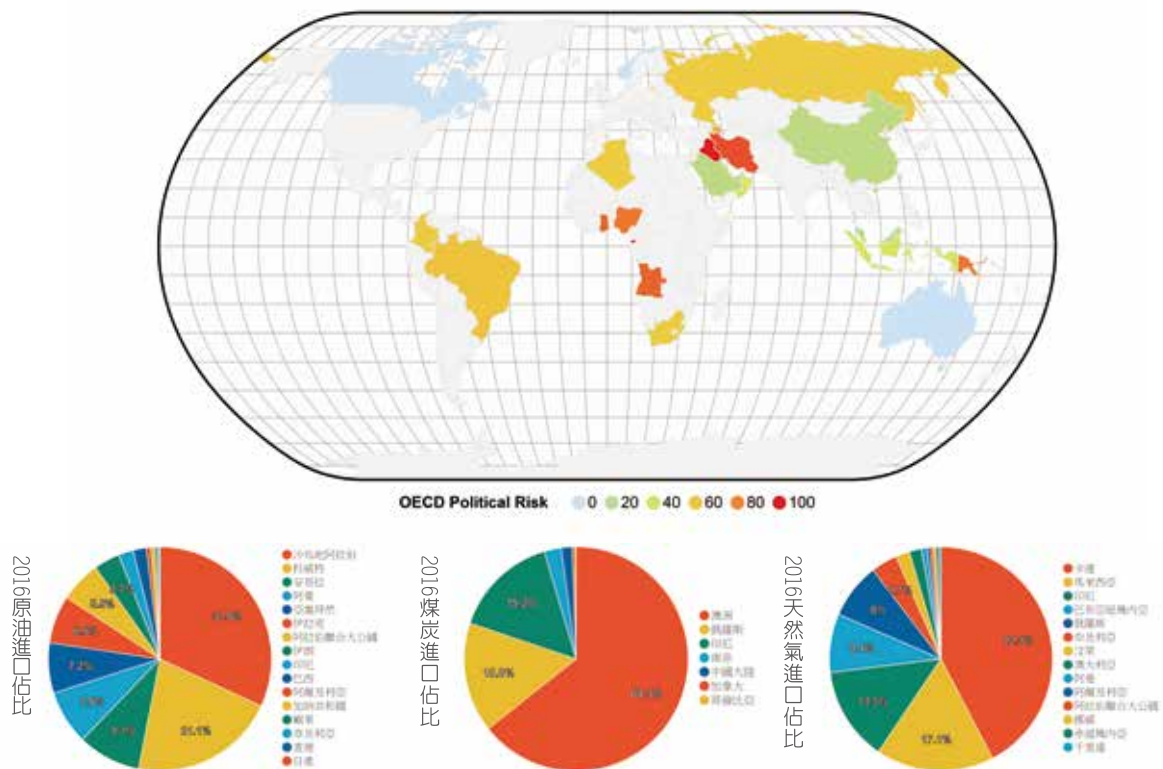
本研究建構之台灣能源經濟脆弱度涵蓋了 1990 年第 1 季至 2017 年第 2 季的數據，編制結果摘述如下：

### (一) 初級能源供應脆弱度

1990 年因伊拉克入侵科威特，使得當時我國原油供應風險偏高，直到波灣戰爭結束之後，才逐漸回降。2000 年後，中東地區雖偶有緊張情事，但 OECD 仍調降阿曼、科威特等中東國家之國家風險，促使我國原油進口風險漸次降低。此外，早期我國煤的進口來源國

集中於澳洲、南非和美國等風險較低之國家，但 90 年代末期至 2000 年時，我國自印尼和中國大陸進口之燃料煤比重大幅提升，導致煤的進口風險一度攀升。近年則將進口來源轉向澳洲為主，使得煤的進口風險走低。在天然氣部分，我國自產天然氣產能持續下降，占比從 1990 年的近六成降低至 2016 年僅有 1%。不過，在分散進口來源國的策略奏效下（除卡達占比 42.3% 最高之外，還包括印尼、馬來西亞、俄羅斯、巴布亞紐幾內亞、奈及利亞、澳洲、阿曼、汶萊與埃及等國），降低我國天然氣供應風險。不過，2017 年 6 月，卡達遭到中東各國斷交，政經風險可能因而增加，值得後續關注（如圖 2 所示）。

整體而言，1990 年代初期，我國初級能源供應以原油及石油產品為主，占比超過 55.9%，故總初級能源供應脆弱度受原油供應風險變化程度較高。而隨著時間推移，我國煤及天然氣占比逐漸提升，2016 年我國初級能源占比分別為原油 48.9%、煤 29.0%、天然氣 13.5%、其他 8.6%（如圖 3 所示）。總初級能源供應脆弱度在更為分散的能源結構及較低的進口國政經風險下，大致呈下降趨勢。2017 年第一季一度降低至資料期間的低點 30.28，2017 年第二季脆弱度則小幅上升至 32.46（如圖 4 所示）。然而，由於屬於類自產能源之核能發電占比持續降低，天然氣進口漸次攀升，我國未來總初級能源供應脆弱度將更容易受到天然氣供應風險變化影響。



資料來源：Country Risk Classification (OECD)，本研究繪製。

圖 2 我國初級能源進口結構與進口國風險

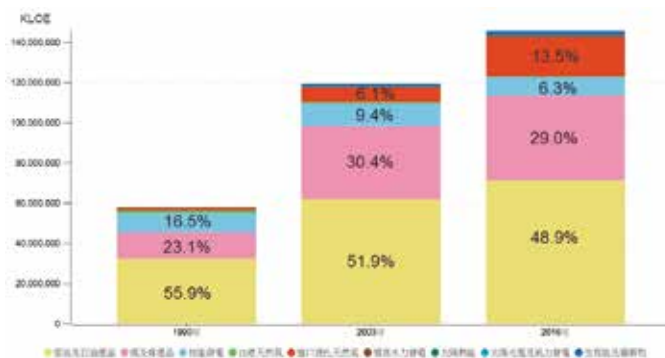


圖 3 我國初級能源結構

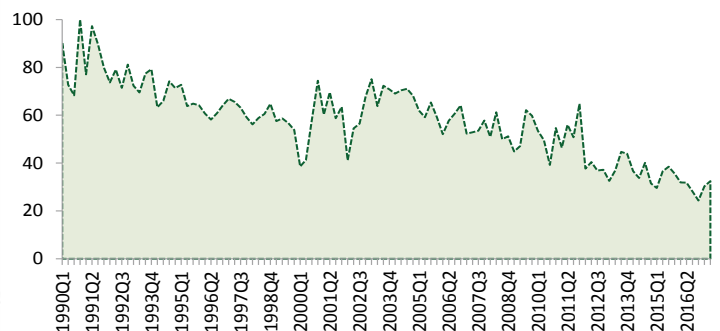


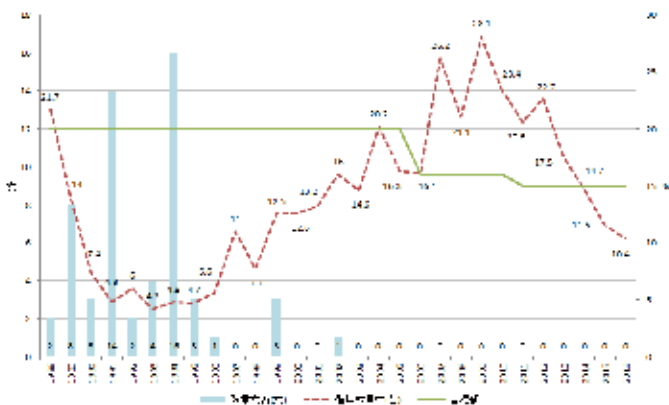
圖 4 初級能源供應脆弱度（1990 年第 1 季~2017 年第 2 季）



## (二) 基礎設施脆弱度

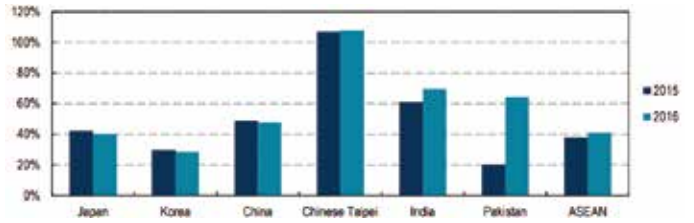
1990~2000 年間，我國實際備用容量率長期低於最適備用容量率，限電次數共 46 次，其中 1994 年曾一年高達 16 次之多（如圖 5 所示）。加上電力生產結構風險偏高，使得當時我國基礎設施風險居高不下。2000 年後，我國備用容量率提升、電力管理能力改善，電力供應相對充裕，加上 2006 及 2009 年永安接收站儲槽擴建及台中接收站儲槽分別完工，有助於增加天然氣安全存量天數，進而有效降低基礎設施脆弱度。然而，近年來因備轉容量率屢創新低，2016 年曾出現 77 天供電警戒的橘燈，甚至有 3 天出現限電警戒的紅燈。今年以來（統計至 2017 年 7 月 31 日），雖然未出現紅燈，但也亮了 58 個橘燈。加上北部電廠面臨停用與除役的限制，區域供電日益不均，隨著天然氣佔我國能源供給的比率上升，我國液化天然氣設備利用率遠高於亞洲其他液化天然氣使用國（如圖 6 所示），而近年天然氣月周轉次數又回升到歷史高點，進口來源若出現中斷（例如颱風），可撐天數僅餘八日。在此狀況之下，基礎設施脆弱度已於 2017 年第二季惡化到 97.94，已臨近 1990 年代的限電局勢（如圖 7 所示）。

若未來核能全面停用，加上協和電廠除役，淡水河以東的大台北地區將無電廠，必須仰賴中南部電廠支援。再考量未來興建的再生能源亦多集中在中南部，將使得中北輸電幹線承擔極大的送電壓力。此外，天然氣第三接收站的興建若不能如期完成，天然氣儲輸設施的營運壓力將面臨極大挑戰。最後，我國負載率極高（近五年平均 82%，遠高於主要國家的 59%~77%），代表所有機組都處於高運轉狀態，容易因為電力需求突增而跳機，亦顯示未來進行負載轉移的空間餘裕有限，無法抵消電力供應緊澀狀態，使得基礎設施脆弱度難有回降的機會。



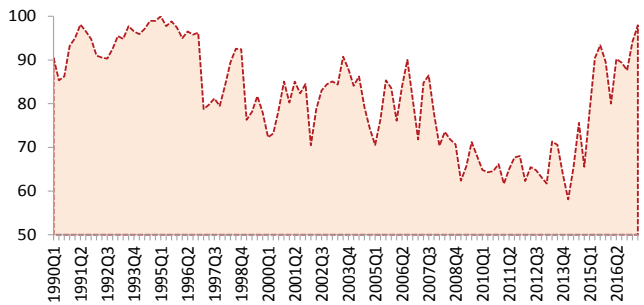
資料來源：本研究繪製。

圖 5 我國歷年備用容量率實績與限電次數



資料來源：IEA analysis based on GIIGNL (2016), The LNG industry in 2015; ICIS (2016), ICIS LNG Edge; IEA estimates.

圖 6 亞洲國家 2015/2016 年液化天然氣設備利用率

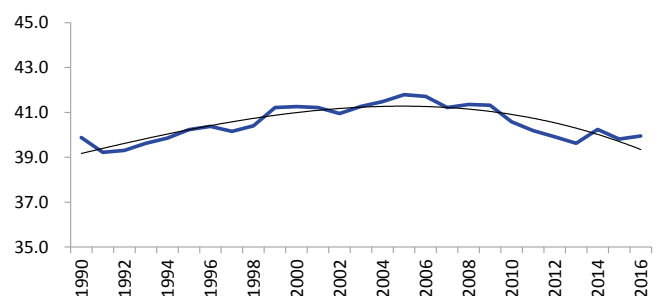


資料來源：本研究計算。

圖 7 基礎設施脆弱度（1990 年第 1 季~2017 年第 2 季）

## (三) 最終能源消費脆弱度

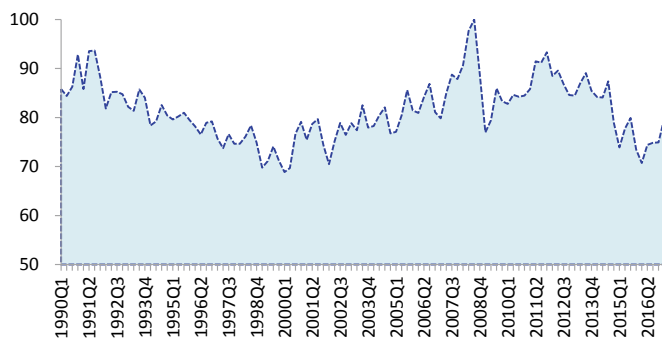
我國進口能源占比達 98%，故深受國際能源價格波動影響。國際能源價格曾於 2008 年達到歷史高點，並於 2008~2009 年間因美國次貸風暴引發全球金融危機、2014~2015 年間因原油供需失衡促使油價兩度大幅下降，國內能源消費者所面臨之劇烈波動的進口能源價格風險難以消弭。早期國內再生能源僅水力發電，發電成本低。近年太陽能與風力發電的占比增加，使得再生能源（含水力）的平均發電成本逐漸走高；加上核能發電的平均成本因為核能電廠發電實績衰退，平均每度核能發電將分攤較高的核後端成本，使得國內整體零碳發電成本走高。於此同時，我國能源密集度持續降低，表示生產每一單位附加價值時，所需之能源越來越少。可提高能源用戶因應能源價格上漲的能力，進而減少最終能源消費脆弱度。最終能源消費結構的集中度則於近年出現微幅下降（如圖 8 所示），抵銷因基礎設施脆弱度上升而使最終消費結構風險上升的幅度。



資料來源：本研究計算。

圖 8 最終能源消費結構集中度

整體而言，最終能源消費脆弱度仍處於歷史相對較低的水平（如圖 9 所示）。但考量目前由於現階段國際煤炭價格、原油價格和天然氣價格相較過往為低水準，惟未來價格上漲可能性高，將增加能源進口成本。燃煤發電占比先升後降的政策規劃（燃煤發電占比先於 2020 年達到 50%，再逐年降低到 30%）、燃氣發電比重提高，加上再生能源發電比重提升及核能電廠除役。以及近年出現電力消費成長率大於經濟成長率，顯示電力使用效率低落等。上述因素都有可能增加消費面的不確定因素，甚至可能造成我國最終能源消費脆弱度的惡化。



資料來源：本研究計算。

圖 9 最終能源消費脆弱度 (1990 年第 1 季 ~ 2017 年第 2 季)

#### 四、政策意涵與建議

隨著進口來源分散以及進口來源國之風險較低，使得初級能源供應脆弱度處於歷史低點。而基礎設施則是近年相對脆弱的層面，隨著我國發電結構之燃氣發電占比提升、核能和燃煤發電占比下降，國內面臨天然氣接收站容量不足的挑戰，不但天然氣安全存量偏低，天然氣周轉次數更快速提升，一旦來源中斷，可撐天數極低。另外，近年來我國備用容量率和備轉容量率持續偏離最適值，且區域供電亦吃緊，雖然電力設備利用率提升，但仍無法抵消電力供應設備不足所造成的風險。因未來天然氣和再生能源設置有不確定性，且隨著日後電力需求量持續增長，與核能電廠除役、未來抑抵尖峰空間有限等因素，基礎設施脆弱度將逐漸提高，限電危機如影隨形。同時，消費面的表現則相對持平，雖然在政府推動各項措施（含價格合理化）下，我國能源使用效率持續提升，惟 2015~2016 年後電力效率有惡化趨勢。且最終能源消費結構風險受基礎設施脆弱度上升而增加、國內能源成本亦可能因再生能

源發電成本和核能發電提前除役成本增加，不利於我國最終能源消費脆弱度的持續改善。

面對短期可見的限電危機，政府當前的相關對策包括：緊急通過協和、通霄等電廠延役。協調地方政府展延麥寮燃煤電廠執照。於大潭新增二部單循環氣渦輪機組，各 30 萬瓩，作為緊急供電機組，加入夏天供電行列。原委會通過核二廠燃料池擴充相關計畫，重啟核二廠一號機。另外以每度 10~12 元代價要用戶自動限電等方式，進行負載管理等供給面與需求面做法來因應，但上述對策多半屬於短期措施，目的僅是延緩限電壓力，難有釜底抽薪之效。而本研究根據上開數據分析後，提出結論與建議如下：

1. 政府宜務實評估能源轉型的方向、目標與期程。
2. 要達成政策目標，政府宜保有彈性空間，來妥善運用各類型的發電機組。
3. 目前應對供電缺口的短期應變措施，仍應考慮投入成本與環境承受能力。
4. 加速增設天然氣接收及輸儲設施，以降低供氣中斷的風險。
5. 目前抑低尖峰負載的空間有限，加上長期存在的區域電力供需失衡的狀況，不能僅靠需求面管理，增加電力供應才是根本之道。
6. 為推動再生能源，宜早日投入分散式能源系統的建置，才能在充分運用各類再生能源的同時，降低對電力系統穩定性的影響。
7. 提升能源效率仍為降低最終能源消費脆弱度的有效方式，政府不宜再對能源價格進行補貼，透過能源價格合理化反映真實成本，才能有效導正能源用戶的消費行為，進而增進能源效率。

註：

- 1 WEC, 2010, "Sicherheit unserer Energieversorgung – Indikatoren zur Messung von Verletzbarkeit und Risiken," Untersuchung im Auftrag des Weltenergiarat – Deutschland. (德文報告)
- 2 研討會的會議資料請至本社網站下載。
- 3 Frondel, Manuel, Nolan Ritter, and Christoph M. Schmidt, 2009, "Measuring Energy Supply Risks: A G7 Ranking," Ruhr Economic Papers.



# 糧食、能源、水資源鏈結 (FEW Nexus) 發展趨勢與應用潛力

環境技術發展中心 鄧倫主任 · 呂雨龍副工程師

水、糧食、能源一直以來都是全球重要的議題之一，過去的研究多針對單一課題進行討論，如能源不足、糧食匱乏或糧食安全、乾淨及安全水源的缺乏等課題進行研究，已有相當豐碩之研究成果。然而，水、糧食、能源問題相互牽連，現今的社會已無法針對這些課題單獨進行分析。舉例來說，水資源處理以及配送需要消耗能源，但水同時可以做為發電產生能源，亦可以提供灌溉所需，提供糧食作物、經濟作物及能源作物的生長，而能源作物亦可透過轉換來生產提供能源。作物在生長過程中的耕作活動需要透過能源提供農業機械設備所需動力，作物的運送過程亦須消耗能源，種種分析結果皆顯示水、糧食及能源問題相互影響，若想要解決水、能源及糧食所面臨的問題，勢必無法針對單一問題進行分析，而須以糧食-能源-水鏈結 (Food-Energy-Water Nexus, FEW Nexus) 進行整體思考，以提出全面且綜合之解決方案。

本社定位為臺灣環境及能資源智庫，為了解水、能源、及糧食三者競合關係，與成大林財富教授及台大林裕彬教授共同舉辦專題研討會與座談會，並出版「糧食、能源、水資源鏈結 (FEW Nexus) 發展趨勢與應用潛力」專題報告，內容摘錄如下。

## 一、舉辦「糧食、能源、水資源 (FEW) 鏈結探討」國際研討會與座談會

去 (105) 年 9 月 5 日假福華文教會館 14F 貴賓廳，舉辦「糧食、能源、水資源 (FEW) 鏈結探討」國際研討會，邀請美國、日本與泰國學者及國內 4 位專家學者，分享推動糧食、能源、水資源 (FEW) 鏈結之現況與展望。當日出席相當踴躍，共 101 位產、官、學、研領域專家出席。9 月 6 日則舉辦「糧食、能源、水資源 (FEW) 鏈結探討」座談會，由本社潘文炎董事長及台大林裕彬教授共同主持，成大林財富

教授引言，13 位國內外專家學者與政府代表與會，針對國內適合 Nexus 的情境與政府如何參與及應用 Nexus 分析推動政策進行討論。

## 二、FEW Nexus 之方法論發展現況

目前重要鏈結研究機構包括國際農糧組織、世界經濟論壇、國際永續發展組織、聯合國環境規劃署、以區域性發展為目標的國際山地綜合發展中心，以及波恩水資源能源糧食鏈結會議等組織。不同組織對鏈結議題有不同的方向與預期目標，對鏈結系統也有不同的定義與詮釋，因此建立的模型與執行的方向也有些微差異，以下就各組織對於鏈結議題的分析概念進行描述。

### (一) 國際農糧組織 (FAO)

國際農糧組織提出的水資源、能源、糧食鏈結方法，考量環境、經濟、及社會永續目標、以及不同群體與環境的需求與利益綜合評估後，在其中取得穩定之平衡。該概念模型定義出了人類與自然環境系統的複雜交互關係，將自然資源 (水、能、土地) 與社經資源 (資金、勞力) 定義為基礎資源，透過鏈結、管理並利用基礎資源，加上水、能源、糧食的支援，進而達成在社會、經濟與環境上的目標與利益。

### (二) 世界經濟論壇 (World Economic Forum)

世界經濟論壇在 2011 年提出的概念模型，目標在於幫助決策者，對潛在風險有更清楚的了解，以在危機處理與應對決策時能積極果斷並有效動員執行。例如全球總體經濟的失衡與非法經濟猖獗，糧食和水資源的安全可能受到衝擊，導致長期水資源與糧食的短缺與危機；另一方面，能源短缺對經濟增長和社會穩定也會造成影響。此鏈結模型並考量包括環境壓力、人口與經濟成長等因素之衝擊，對糧食、能源、水資源鏈結造成的影響，例如空氣污染、生物多樣性喪失、氣候變化、洪水、海洋治理、颶風、地震和火山爆發等。



### (三) 國際永續發展協會 (IISD)

國際永續發展協會所提出的方法，較著重在生態系統的管理，並整合政策發展、土地與農業投資，以及對風險與機會的調適性管理 (adaptive management)。該概念模型是以流域 (集水區) 生態系統為基底，指出在確保對生態系統產出與服務有良好管理，就能將水資源、能源、糧食鏈結的安全最大化。

### (四) 聯合國環境規劃署 (UNEP)

在水資源、糧食、能源鏈結的探討中，聯合國環境規劃署也提出以生態系統為導向的概念模型，將生態系統定義在水資源糧食能源的裡外層，同時也探討土地與氣候變遷與生態系統的關係，以期建構水、糧、能的安全與永續鏈結。

### (五) 國際山地綜合發展中心 (ICIMOD)

國際山地綜合發展中心所提出的概念模型，發展起源是為了規劃喜馬拉雅山與南亞跨國的區域性永續發展與政策規劃。由於南亞區域與喜馬拉雅山區息息相關，因此鏈結喜馬拉雅山的生態系統服務，非常具必要性。此模型的核心是生態系統服務 (ecosystem services)，鏈結的方法並非按部門劃分，而是以整合化系統性的結構，希望減少權衡間的損失而能雙贏共利。在概念模型中，生態系統所提供的服務是關鍵的元素，用以鏈結水資源、能源、糧食運作，進一步保障三者的安全。因此，在概念模式中不論是在環境規範與技術應用，都是以對生態系統服務的保護，以及以確保 / 增強其韌性和產出為最高指導原則。

### (六) 波昂會議 (Bonn Conference)

2011 年在德國波昂召開的水資源、能源、糧食鏈結研討會，是第一個專門討論三者鏈結的會議。會中提出重要的概念模型，以嶄新「鏈結」導向的方法，試圖提出解決非永續與資源短缺的辦法，以確保水資源、能源、糧食等三

者的安全與永續，進而評估貿易、投資與氣候政策對三者鏈結的影響。

## 三、以 FEW Nexus 分析台灣現況

### (一) 台灣糧食、能源、水之關聯性分析

糧食的生產量、能源的消耗量以及水資源的使用量，三者之間具有相當的關連性，表 1 顯示全台灣從 2003 年到 2013 年，以縣市為單位，糧食、能源、水彼此之間的平均相關係數。用電量與工業用水量以及民生用水量呈現高度的相關性，主要的原因有二，工業地區本身就會消耗較多的電力，以及水資源來維持工廠的運作，至於一般居民居住的地區也有此現象，人口較多的地區的民生用水量與用電量應較高於人口較少的地區，因此用電量會與工業用水以及民生用水呈現顯著的相關性。

其他彼此之間呈現較高相關性的因子還有灌溉用水以及稻米產量，在生產稻米的過程中，需要大量的灌溉用水，因此在稻米生產較繁盛的地區會需要較多的灌溉用水。除了探討三者之間在過去 10 年之相關係數的平均外，表 2 呈現 2003 年與 2013 年，糧食、能源、水彼此之間的改變率的相關係數，彼此之間有相關的因子為用電量與稻米產量，兩者之間呈現顯著的負相關 (-0.69)，主要的原因可能為某些地區在過去 10 年快速的工業化發展導致用電量上升，例如：台中市，然而從事農業的人口下降，稻米的產量銳減，導致兩者呈現負相關。

表 1 糧食、能源、水彼此之間在過去 10 年之平均相關係數

	用電量	工業用水	民生用水	灌溉用水	稻米產量
用電量	-	0.71	0.76	-0.12	-0.06
工業用水	0.71	-	0.28	0.11	0.42
民生用水	0.76	0.28	-	-0.13	-0.13
灌溉用水	-0.12	0.11	-0.13	-	0.61
稻米產量	-0.06	0.42	-0.13	0.61	-





表 2 糧食、能源、水彼此之間的改變率 (比較 2013 與 2003) 的相關係數

	用電量	工業用水	民生用水	灌溉用水	稻米產量
用電量	-	0.09	0.03	0.01	-0.69
工業用水	0.09	-	0.22	-0.39	-0.13
民生用水	0.03	0.22	-	0.05	0.09
灌溉用水	0.01	-0.39	0.05	-	-0.07
稻米產量	-0.69	-0.13	0.09	-0.07	-

## (二) 台灣 FEW Nexus 背景評析

依照國際農糧組織的鏈結方法論中的快速評析方法，針對台灣糧能水鏈結的狀況進行背景分析 (context analysis)。此評析方法首先將各國依發展狀況、與先天條件分為下列四個國家群類型，而台灣則屬於其中第三種類型：

1. 以農業為主要經濟之缺水國家：農產業人口 > 20%、且再生水資源 < 1,500 立方公尺 / 人口 / 年。
2. 以農業為主要經濟之豐水國家：農產業人口 > 20%、且再生水資源 > 1,500 立方公尺 / 人口 / 年。
3. 缺乏天然資源、但較富裕國家：農產業人口 < 20%，且 > 20% 的能源與農產品進口。
4. 人口大量成長的轉型國家：人口增長率 > 0.5%。

利用本方法進行背景評析時，除考量糧食、能源與水等項目之外，尚需考慮勞力與資金，其中勞力部份包括人力資源需求的密集程度與薪資水平等因素，而資金則與成本與投資水平相關。評析時所使用之指標，係由國際農糧組織制定，各指標為國際間所使用的永續指標，四個不同類型的國家使用不同指標；評析時，水資源、能源、糧食、勞力與資金等 5 個項目，每個項目各使用兩種指標，合計共 10 種指標 (如表 3 所示)。

本次分析所參考的永續指標及資料來源分

別如下：水資源方面是以再生水資源 (地表截流之天然降雨) 的使用比例作為水量分配的指標，以農田用地內的水質監測站為單位，在氮磷與農藥等項目有水質超標的比例，作為水質安全的指標。能源方面是以能源進口依賴比例作為能源安全指標，以化石能源的使用比例作為減碳永續指標。糧食方面是將農產品進口總值除以總人口數，作為每人依賴國際糧食供給評估為糧食安全指標，及農地使用面積近 10 年間的變化率作為農業發展評估指標。勞動力資源主要考量農業發展，以製造業人均收入除以農民人均收入，及從事農業之人口比例。資本方面以農業的人均生產毛額作為農業投資報酬率的評估，及國內生產總值中投資研發所佔的百分比作為經濟發展潛能指標。依國際農糧組織方法，上述 10 項指標可作為評析臺灣糧能水背景狀況的指標，提供鏈結評析用。

在分析各指標時，係以同一類型的國家群之平均值作為參考基準，再以評析標的 (國家) 與參考基準間差異的百分比得出差距比例，其中不同類型國家、各指標的基準值，可參考國際農糧組織報告。以再生水資源使用比例指標為例，國際農糧組織由第三類型的國家之平均數值所訂出的參考基準是 40%，而台灣是 30%，因此差距比例以 30% 與 40% 相減，再除以 40% 作為標準化的運算功能，得出差距比例為 -25%。差距比例如果為 0% 時，計為 2 分，因此將差距比例加上 2 (分) 則為該指標之分數，因此水資源再生使用比例為 2 加上 -25%，評分為 1.75。各項目計算出後，再由每個項目 (糧、能、水...) 內對指標之權重進一步算出綜合評析的分數，權重指數可透過各相關單位研擬討論訂定之，但在本評析則維持原建議值之權重。

由各分項分數加上權重之比例得到綜合評分，從 1 到 3 分，分別代表生物經濟資源的壓力指數，作為評析標的整體背景狀況描述，分



數越大則代表該項目較為緊縮之資源。為提供決策者視覺化的結論，國際農糧組織以綠色、黃色、紅色分別以 1、2、及 3 分表示；以水資源為例，1.75 與 2.45 分別乘上權重比例而能得出綜合評分 2.17，能進一步作為永續發展評出的背景指標。

參考表 3 分析結果以及圖 1，可得知台灣的糧能水鏈結中，水資源、勞力、及能源是為較緊縮之資源 (分數依序為 2.17、2.15、及 2.11；圖中顏色較偏黃色)。在水資源方面主要因土地利用密集，氮氫含量於水質出現之比例仍偏高，為水資源利用上的威脅；而大量的進口能源與高比例的石化燃料也是台灣能源上的困境。在糧食進口方面則呈現較低的比例，仍為優勢之一，而在勞動力供給方面，農業人員薪資與從業人口皆有較低的的比例。整體而言，台灣的評析結果並未出現極差 (3 分) 的緊縮資源，是較均衡之鏈結現況。

#### 四、台灣推動 FEW Nexus 方向與作法

##### (一) 建置國家層級整合性數據平台

在 FEW 鏈結研究上，常見的障礙是數據的取得與驗證，特別在跨部會與組織管理下，數據往往難以取得齊全。在許多研究經驗與工具開發而言，多以國家層級之尺度規模的數據



圖 1 台灣糧能水鏈結背景評析圖

使用為最大宗，以長期而觀，在因應氣候變遷、人口快速成長與全球經濟的不穩定性所加總之風險因素，健全數據平台更將是優質國家級策略發展之基礎，更是對國家在未來推動管理上的創新轉型與政策發展具樂觀可期性。

我國目前在各級單位皆有分屬之資料庫及其應用，作為鏈結綜合系統之基礎。在農業上，利用區域數據預測農業生產、制定調節、評估災損並可作為擬定農地規劃利用政策的參考，民間組織如台灣農業推廣學會也建議農業主管機關，可與農業大專院校合作建置農業推廣資料庫，目前行政院農委會也正在推動農業生產大數據。能源方面，資料庫部分有能源局

表 3 台灣糧能水鏈結背景評析結果

評析指標	評比標的	參考基準	差距比例	權重	評分	綜合評分
總用水量 / 再生水資源 (2000 - 2009 平均)	30%	40%	-25%	2	1.75	2.17 (水資源)
農業區域水源 (地表與地下) 超過飲用水水質標準之比例，包含氮、磷與殺蟲劑 (2015)	42%	29%	45%	3	2.45	
化石能源占總能源供給 (百分比，2015)	90.8%	88%	3%	3	2.03	2.11 (能源)
進口能源 (百分比，2015)	98%	80%	22%	2	2.22	
人均農產品進口總值 (千美金 / 每人，2015)	0.636	13.523	-2127%	2	0.00	0.58 (糧食)
農地使用變化率 (百分比，2005-2014)	-1.20%	-7.30%	-84%	2	1.16	
製造業平均收入 / 農業生產平均收入，2015	1.86	1.42	31%	1	2.31	2.15 (勞力)
總農業從業人口 / 總就業人口，2015	0.0495	0.045	10%	3	2.10	
總農業從業人口 / 農業總生產毛額 (人口數 / 1,000 Int.\$，2015)	0.056	0.096	-42%	1	1.58	1.83 (資本)
投資佔國內生產總值 (GDP) 的比重，2015	20.26%	22.30%	-9%	3	1.91	





提供的統計資料與台灣綜合經濟研究院所建置之能源指標資料庫，但在能源用戶端之相關資料建置仍有缺乏。水資源方面，不同用水標的分屬在不同管理單位，因此在整合水資源分配與利用之數據建置仍較困難，而就灌溉用水之監測管理而言，仍需技術與設備上的提升。環境數據方面，環保署長期針對污染物與相關環境監測提供開放資料，可作為參考。以日本為例，目前日本建設部從蒐集各單位數據到可提供上線參考的耗時長，且僅授權線上閱讀，無法下載，因此在建置初期的共識與各部會彼此間的信任格外重要，此外，大數據資料庫建置可參考澳洲聯邦科學與工業研究組織 (the Commonwealth Scientific and Industrial Research Organisation, CSIRO) 所建置之資料庫。

## (二) 訂定綜合管理相關法規：農業回流水、再生水

在台灣各類用水量與比例，係長期經驗與解決實務問題之結果，要有大的變更，相當不容易；且在各環節之調配與新科技之使用上，仍有精進的空間。目前水處理與水再生程序中，氮、磷的控制仍是關鍵，若能建立廢液回收系統，可降低水處理能源的使用，回收的鳥糞石亦可作為作物之肥料，是值得研發推廣的技術，亦符合 FEW 鏈結之精神。

歐盟將畜牧廢水視為肥分，禁止排放河川，經處理後回灌農田、或乾燥焚燒發熱或發電。我國水污法施行以來，為避免畜牧廢水污染河川而嚴加管理，必須經厭氧發酵、減臭、減少致病菌、提高氨氮比率等處理後才可排放或回灌農地。若農戶未取得肥分使用計畫，逕行將畜牧廢水回灌自家農地，將處罰鍰。畜牧廢水回灌農地的優點為大幅減少水污費、滋養土地及減少使用化肥，這需要在法規中制定。

反觀日本現面臨自然水資源之水質太過乾淨而缺乏養分的問題，造成漁場藻類繁殖困難。現在日本在水資源管理上，各類水資源管理依法律賦予的許可權分屬不同主管機

關管轄，如國土廳負責水資源的管理，農林水產省負責灌溉排水的工作，通商產業省負責工業用水，厚生省負責生活用水，儘管 2014 年日本已通過水循環法，但各部門間之溝通仍頗具困難度。此外，法案的建置需考慮到執行面，以日本為例，海洋法案從中央立法到地方落實執行最終共耗費十年之久；對於跨域整合管理的經驗，美國由 13 個聯邦政府部門合組 U.S. Global Change Research Program (USGCRP)，共同尋找未來研究方向或面臨問題 (如各部門研究範疇重疊)，並定期討論，雖然過程困難又耗時，但目前已有初步成果。

## (三) 健全智慧農業、智慧灌溉用水管理系統

雖然台灣面積小，但各區域的都市化、農業種植，氣候特徵均有相當程度差異，因此在探討 FEW NEXUS 時，需將時間因子 (如豐枯期) 和空間因子 (如南、北、東部或是集水區、灌溉區等) 納入考量。智慧農業之發展，乃藉由科技及技術發展的智慧系統栽種農作物，追求農產品的高效率、高品質及產量穩定，以提升我國農業競爭力及帶動農業升級；而以鏈結方法進行整合評估是以協助推動之助力。

目前研究多重視各鏈結問題，如量的平衡，而且是直接供給與消耗，事實上，在水資源、能源、食物的供應和生產上，間接消耗量亦必須考量；另一方面，各面向量的增減，是不同單位而難以權衡比較，且不同方式的資源使用將產生不同的衝擊。因此未來研究也建議以生命週期思維，建構全階段的環境衝擊比較，再輔以經濟價值的估算，做較周全的可行發展方案比較。雖然目前生命週期衝擊評估方法仍有需改善之處，特別是對於水及土地的衝擊，但仍建議初期先採用國際上較普遍使用的方法建構雛型，再逐步做細緻化、本土化之修正。

<詳細內容請參見「糧食、能源、水資源鏈結 (FEW Nexus) 發展趨勢與應用潛力」專題報告，歡迎至本社網站 [www.ctci.org.tw](http://www.ctci.org.tw) 下載 >



## 穿梭時空的 手繪城市速寫

畫家 張柏舟

並發表在 FACEBOOK 上；每月例會活動則有近百人的盛況，有興趣的同好就借此機會前往觀摩參與。

張柏舟教授取得美國 IOWA 州立大學藝術與設計碩士學位，即返母校台灣師範大學設計研究所任教；在產學合作的體制下，以學貫中西的美術理論與設計理念，帶領學生參與無以數計的設計案。2009 年自台師大設研所所長職務退休，2012 年受邀加入陳文盛教授創立的「Urban Sketchers Taipei 速寫·台北」(<https://www.facebook.com/groups/usk.taipei/>) 社群。由於張教授等熱心人士的投入與分享，目前累積成員近 22,000 人。

「Urban Sketchers」(<http://www.urbansketchers.org/>) 是西雅圖記者 Gabriel Campanario 於 2008 年，以「速寫·看見世界」的構想，發起手繪居住或旅行城鎮而成立的 NPO。2012 年初，集結來自世界各地的傑作，發行《The Art of Urban Sketching》並譯成多國版本，中文版《手繪城市》於 2013 年初上市。張教授認為速寫講求的是記錄生活周圍環境的一切，未必要畫得很像，可以有畫意；他以 Drawing、Painting、Sketching 說明其間的差異：Drawing 是繪畫的基本如素描，Painting 是繪畫創作，Sketching 則是當場快速畫下實景的動作；所以即使沒有繪畫基礎，也可以加入速寫的行列，只要有興趣用手上的筆勾繪所看到的實物。

速寫是將周遭觸目所及的人事物，運用鉛筆(2B~4B)、鋼珠筆、代用針筆(0.5、0.7)、美工(書法)鋼筆等簡單熟悉的工具，結合淡墨、水彩等顏料(或僅線繪亦可)，在畫紙上描繪當下對實境的認識。速寫不必害怕畫錯，只要畫出所看到的形象感覺，畫出自信。全省各地速寫的成員包含退休人士、家庭主婦、上班族、自由工作者，大家利用晨間、午休、下午及周休日，搭乘大眾運輸工具，相約畫聚即興速寫並相互分享作品、觀摩交換意見，

如果公司内部成立速寫社團，張教授建議不要太一般正規美術體制下學習的觀念；不妨從身邊喜歡又容易畫的東西來培養手繪的能力。美感的泉源往往來自生活中的觀察與體認，平常多看畫、看展、欣賞美的東西，在理性本質中附加感性的薰陶；透過速寫來提升生活的藝術與價值，並獲得心靈的調劑與療癒。張教授非常鼓勵具備特長的速寫者，嘗試開班引導團體走向戶外；讓自身接觸都市周圍景觀，在手繪的樂趣中延續生活故事的呈現，同時在推廣中分享身心的成長與美感的喜悅。

張教授有如燦爛的陽光，充滿生命活力；他覺得退休後的人生不必刻意規劃，而是要讓自己每天有事做又過得快樂。每天天亮之前出門速寫，粉絲們 8 點就等著上網欣賞張教授的晨畫；中午 Line 相約去古蹟舊街，速寫兼覓美食；或者下午再陪伴翹班畫友去畫遠山近水。2014 年，張教授挑選出 2012~2013 年的百餘幅速寫，出版《寫景·寫意 寫出樂活人生》，其中亦詳實介紹速寫的工具與運用。速寫作品沒有好壞，不必有繪畫壓力，善用工具、放手揮灑，自然能夠繪出屬於自己的樂活人生。

採訪整理 / 張兆平 · 許湘琴

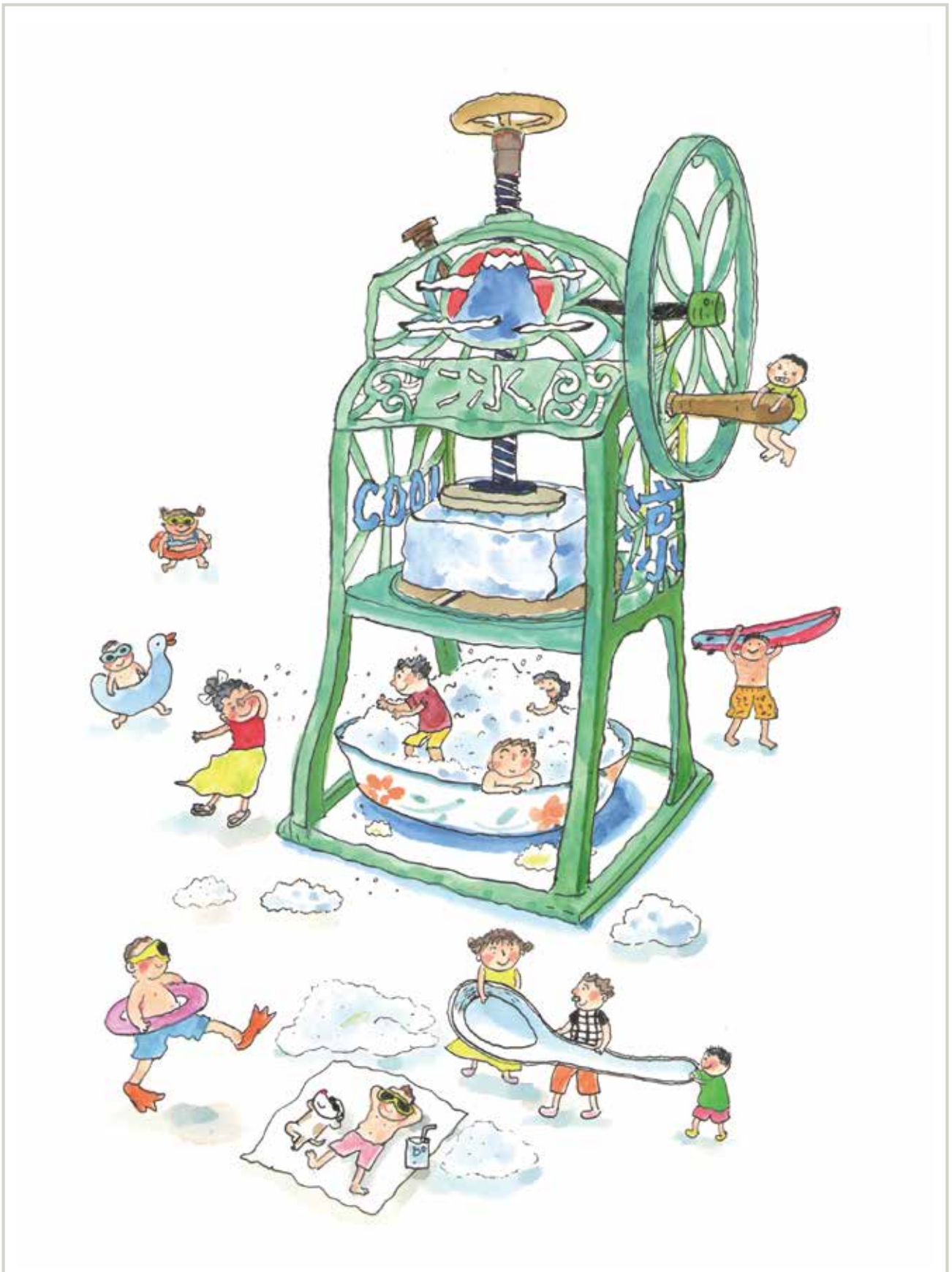


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五臟俱全的 TATONKA 多功能折椅背包





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面對天熱，需要清涼，  
夏天快樂！



## 現場手繪橋與樓

記錄台北北門高架橋的拆除與整治，以及梅雨中的真理大學牧師樓。

26X54 cm 速寫 2017年 張柏舟



財團  
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