Net Zero Tech | International Contest @ Taiwan
2024淨零排放科技國際競賽

決賽手冊
Finale Handbook

國立臺灣大學 National Taiwan University

財團法人東元科技文教基金會 TECO Technology Foundation

Advisory Committee 指導單位：Ministry of Education, R.O.C 教育部　Ministry of Environment, R.O.C 環境部
NTSC, R.O.C 國科會　Ministry of Economic Affairs, R.O.C 經濟部

Co-organizers 協辦單位：Association of Pacific Rim Universities (APRU)
TUASG 臺灣永續治理大學聯盟　National Taiwan University System 國立臺灣大學系統

Sponsors 贊助單位：CPC Corporation 台灣中油(股)公司
NTU ARC-GMST 台灣大學前瞻綠色材料高值化研究中心
NTU AIAD 社團法人臺大產學交流發展協會
Hotai Motor 和泰集團
TECO Electric & Machinery Co., Ltd. 東元電機(股)公司
Nan Pao Resins Chemical Co., Ltd. 南寶樹脂化學工廠(股)公司
Chen-Yung Foundation 財團法人勇源教育發展基金會
Fubon Financial Holding Co., Ltd. 富邦金融控股(股)公司
Hua Nan Commercial Bank Ltd. 華南商業銀行(股)公司
Shiny Chemical Industrial Co., Ltd. 勝一化工(股)公司

目 錄

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人類共同的希望

由地平線上緩緩升起

以企圖完成的圖傳達精緻的思維

集眾領域之智慧及造福人類之共同信念

尋著前人的軌跡

融入新意與未來的想像

攜手邁向零碳未來

2023 年歲末，董事會進入第十一屆，個人受東元電機所託，因緣際會接下基金會推動企業社會責任的任務，董事成員也以世代交替的精神，獲得台灣大學陳文章校長的支持，領航淨零科技競賽的策劃與推動。對於初次擔任企業型基金會董事長的我而言，雖戒慎恐懼，但幸獲陳校長的支持，讓淨零排放科技國際競賽，得以在今年順利以「主競賽」與「國際賽」雙賽制進行的規模擴大辦理。陳校長為了提高競賽的國際影響力，邀請最具國際代表性的大學組織 Association of Pacific Rim Universities (APRU) 協辦之外，並以提高獎金為目標，號召國內富邦金融控股(股)公司、財團法人勇源教育發展基金會、台灣中油(股)公司、勝一化工 (股)公司、和泰集團、華南商業銀行(股)公司、社團法人臺大產學交流發展協會、台灣大學前瞻綠色材料高值化研究中心、南寶樹脂化學工廠(股)公司等十家企業設置獎金支持，促成總獎金達六百五十萬元整的規模。

2024 年競賽在上述的努力中，報名的國際賽團隊達 99 隊、主競賽 141 隊，計來自 13 個國家 240 件作品，參賽的國際淨零菁英師生達 998 人，就人數與作品數量是台灣最具代表性的國際淨零賽事。兩個競賽各精挑 20 個團隊進入決賽，競爭之激烈，足見入圍即是得獎，意即是在場的各位，無論是指導老師還是學生，皆已經是專業評審團認證的淨零精英，也是 2050 淨零的源頭活水。

本屆報名件數多、涵蓋領域極廣，特別感謝十五位評審委員，集中心力且在最短的時間之內完成龐大的作品資料審查與推薦，困難度非常高，決賽現場必須聚精會神戰戰兢兢，使命必達，不僅是對競賽的支持，也是對全球淨零的承擔；謹代表基金會向委員們致上最高的謝忱與敬意。本競賽也同時以嚴謹的作業，希冀打造一個具有「國際影響力的淨零技術競賽、人才培育與產業發展」的基地。在此，特別感謝來自世界各國團隊的參與，深信在競賽的壓力與交流中，皆各有斬獲；且讓我們攜手在全球 2050 淨零的路徑中，以「人才培育」為本，在 2050 淨零的願景中，做出重大貢獻。願「人才與技術」的活水源頭，不斷地注入，讓地球的天光雲影，因為我們的努力，而潔淨而美麗而淨零而永續。

財團法人東元科技文教基金會

董事長 李世光

Together Towards a Net Zero Future

At the end of 2023, the Board of Directors entered its eleventh term, and I was honored to be entrusted by TECO Electric & Machinery Co., Ltd. to take on the task of promoting corporate social responsibility through the foundation. With the spirit of generational transition, the board members received support from President CHEN Wen-chang of National Taiwan University, leading the planning and promotion of the Net Zero Tech International Contest. As a first-time chairman of a corporate foundation, I felt cautious yet fortunate to have President CHEN's support, allowing the Net Zero Tech International Contest to expand this year into a dual competition format, featuring both the "Main Contest" and the "International Contest." To enhance the international influence of the competition, President CHEN invited the Association of Pacific Rim Universities (APRU), one of the most prestigious international university organizations, to co-organize the event. Additionally, with the goal of increasing the prize money, he rallied support from ten domestic companies, including Fubon Financial Holding Co., Ltd., Chen-Yung Foundation, CPC Corporation, Shiny Chemical Industrial Co., Ltd., Hotai Group, Hua Nan Bank, NTU Association for Industry & Academia Development, NTU Advanced Research Center for Green Materials Science and Technology, and Nan Pao Resins Chemical Group, resulting in a total prize pool of NT$6.5 million.

Thanks to these efforts, the 2024 competition received a record number of applications. The international competition attracted 99 teams, and the main competition saw 141 teams, totaling 240 entries from 13 countries, involving 998 elite teachers and students dedicated to net-zero. It is the most representative international net-zero competition in Taiwan in terms of both the number of participants and the number of entries. Twenty teams were carefully selected from each contest to enter the finals, showcasing fierce competition. The intense competition demonstrates that making it to the finals is already a victory, meaning that all of you present, whether you are a supervising teacher or a student, have been certified by a professional judging panel as net-zero elites and are the driving force behind the 2050 net-zero goal.

This year's high number of entries covered a wide range of fields. We are extremely grateful to our 15-member judging committee, who concentrated their efforts and completed the extensive review and recommendation of the submissions in the shortest time possible.

The high difficulty of this task requires intense focus and dedication in the finals. This is not only a support for the competition but also a commitment to global net-zero efforts. On behalf of the Foundation, I would like to express our deepest gratitude and respect to the committee members. With rigorous operations, this competition aims to establish a base for “internationally influential net-zero technology competitions, talent cultivation, and industrial development.” I especially thank the participating teams from around the world, confident that everyone will gain valuable experiences under the pressure and exchange of the competition. Let us work together on the global path to 2050 net-zero, with “talent cultivation” as our foundation, to make significant contributions to the vision of a 2050 net-zero future. May the source of “talent and technology” continue to flow, making our planet’s skies and clouds clean, beautiful, net-zero, and sustainable through our efforts.

Chairman, TECO Technology Foundation

以科技創新 造就新的可能

全球超過 130 個國家承諾 2050 年「淨零排放」目標，其中包括台灣。我們都同意，這是全球性議題，涉及層面廣泛，需要更前瞻、更有效的解決方案，但新技術的發明非一蹴可幾；如何讓更多還在萌芽階段的創新技術有一個發光發熱的機會，就是舉辦這個國際競賽的目的。

臺大一直以培育各領域的領袖人才為使命，對於永續發展更以社會責任自期。這兩年與東元科技文教基金會共同舉辦國際性的「淨零技術競賽」，即是回應社會對大學的期待。所以，這場競賽不僅是一場科技盛宴，更是我們共同致力於促進環境永續發展的重要行動，當然也是展現實力的舞台。

透過這場競賽，我們鼓勵年輕學子投入「淨零排放」的研究和發展技術，同時也促進了全球淨零技術的交流和國際合作的可能，更希望集學界與產業界之力，共同打造台灣成為淨零研究、人才培育與產業技術發展重要的基地。

個人感到非常榮耀，能代表臺大向參加這次競賽的所有師生致意；在你們的創意與專業發揮下所誕生的各種淨零技術方案，讓人看到改變的可能及未來的希望。

最後，感謝所有支持這場競賽的人士和機構，是你們的參與和付出，讓這場活動得以圓滿完成。身兼研究者和教育者，我們會繼續在教學和研究上努力，讓知識與價值能夠更直接地回饋社會，解決問題，不只在關鍵的氣候變遷議題，也在社會最需要我們的地方；讓我們共同朝向永續發展的願景前進。

國立臺灣大學

校長 陳文章

Unleashing Possibilities with Tech Innovations

Over 130 countries, including Taiwan, have committed to achieving "Net-Zero Emissions" by 2050. This global challenge with widespread implications requires forward-thinking and practical solutions. However, groundbreaking technologies don't emerge overnight. The purpose of this international contest is to provide a platform where creative ideas can take root and thrive.

NTU prides itself on cultivating leaders across all dimensions and views the promotion of sustainable development as its key social responsibility. In line with these missions, NTU has partnered with the TECO Technology Foundation to host the "Net Zero Tech International Contest" for the second consecutive year. This competition is not just a demonstration of our technological advancements but also a testament to our collective commitment to sustainable environmental development, where our true strength lies.

Through this contest, NTU not only encourages young scholars to engage in the research and development of zero-emission technologies but also facilitates their collaborations with each other and their global counterparts. By harnessing the collective strengths of academia and industry, we aspire for Taiwan to become an international hub for net-zero research, talent cultivation, and technological innovation.

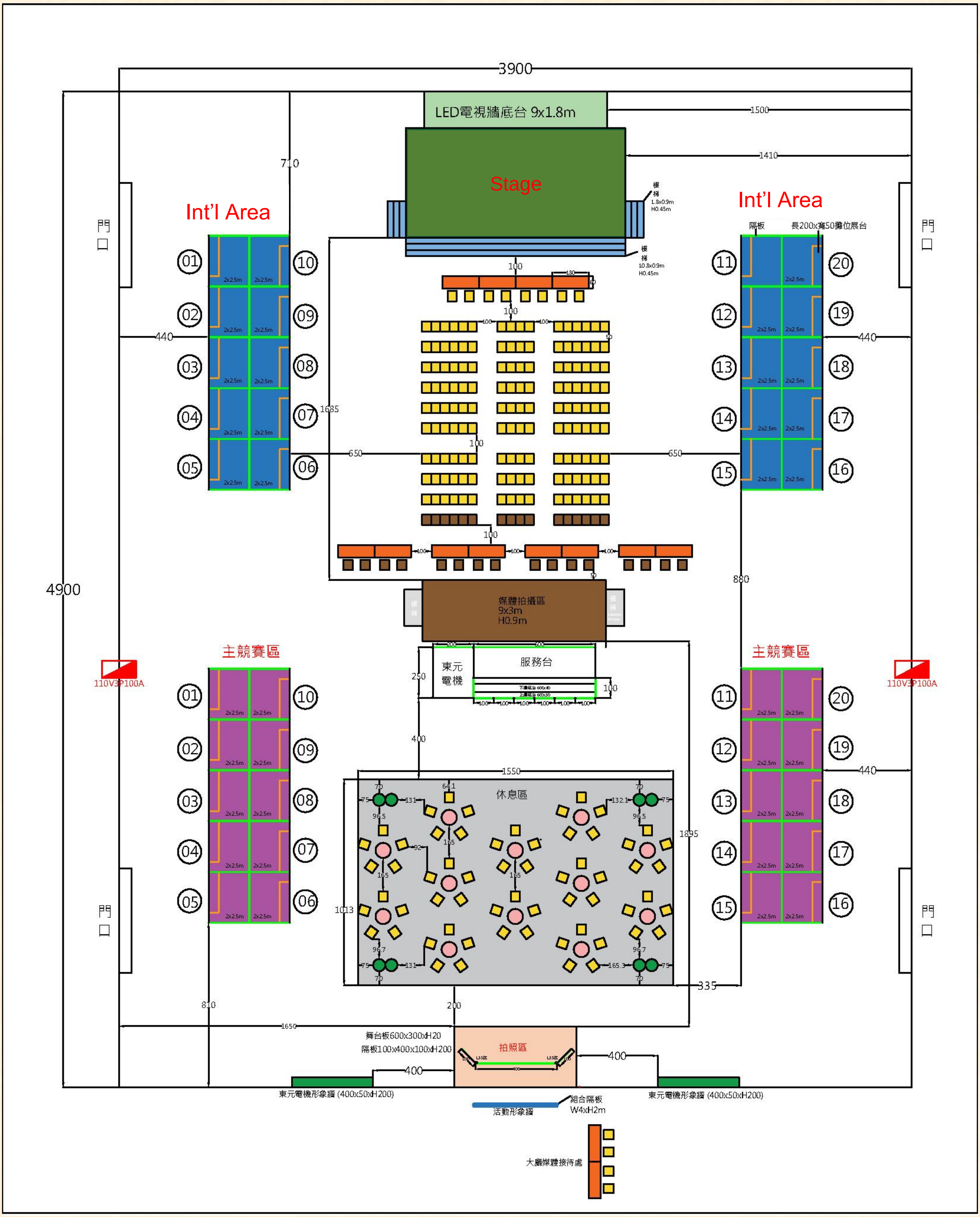
I am incredibly honored to pay tribute on behalf of NTU to the faculty and students who exerted tremendous effort to participate in this competition. With your creativity and technological skills, I am confident that you will bring to the table net-zero solutions that make people believe the ultimate goal is within our grasp.

Finally, I would like to express my heartfelt gratitude to the organizing team. Their tireless efforts and dedication have made this wonderful event possible. As a researcher and educator myself, I will also continue to contribute on both fronts, translating knowledge into practical solutions that can help society address its most pressing issues, climate-related or otherwise. Let's work together towards a sustainable future together. Thank you all.

Wen-Chang Chen

President, National Taiwan University

會場配置圖 Floor plan



大會程序

時間 \ 項目	程 序	內 容	國際賽	主競賽
07:40-08:20	報到 (評審委員 07:50 報到)	參賽團隊-驗證作品組裝		
08:10-08:45		評審作業說明(評審)		
08:50-09:05	評審進場 大會競賽辦法說明	決賽與評審方式說明		
09:10-12:53	簡報與實作- 第一&二階段	國際賽:每隊 12 分鐘 主競賽:每隊 13 分鐘	司儀-李宗霖	司儀-瞿德淵
11:53-12:40	午 休			
12:40-14:50	簡報與實作- 第三&四階段	國際賽:每隊 12 分鐘 主競賽:每隊 13 分鐘	司儀-李宗霖	司儀-瞿德淵
14:51-15:30	作品展示與觀展 (評審計算成績產出得獎名單)			
15:10-15:40	貴賓參觀國際賽作品	導覽-臺灣大學 陳文章 校 長		
	貴賓參觀主競賽作品	導覽-東元電機 范 炘 總經理		
15:40-16:00	貴賓入場	大合照	司儀-李宗霖	
	競賽簡介	影片播放		
	介紹與會貴賓	司儀-李宗霖		
	主辦單位致詞	東元科技文教基金會 董事長 李世光 先生 國立臺灣大學 校 長 陳文章 先生		
16:00-16:45	頒獎 I 主競賽	華南銀行零碳希望獎	華南銀行 黃俊智 總經理	
		和泰前瞻綠能獎	和泰集團 陳贊文 部 長	
		勝一節能創新獎	勝一化工 孫啟發 總經理	
		台灣中油智慧能源獎	台灣中油 林珂如 執行長	
		季 軍(勇源永續發展獎)	勇源基金會 陳致遠 執行長	
		亞 軍(勇源淨零科技獎)		
	頒獎 II 國際賽	南寶樹脂零碳希望獎	南寶樹脂 沈永清 副總經理	
		前瞻綠能高值獎	台大前瞻中心 陳文章 校長	
		前瞻綠能產協零碳希望獎	台大產協會 翁素蕙 理事長	
		台灣中油智慧能源獎	台灣中油 林珂如 執行長	
		季 軍	國科會 林法正 政務副主任委員	
		亞 軍	工研院 吳政忠 董事長	
	頒獎 III 主競賽冠軍	冠 軍(富邦淨零科技獎)	富邦金控 蔡明興 董事長	
	頒獎 III 國際賽冠軍	冠 軍	東元電機 利明献 董事長	
	冠軍團隊與主辦單位、設獎單位合影		國立臺灣大學 陳文章 校 長 東元科技文教基金會李世光董事長	
16:45-16:50	公布人氣獎得主&摸彩東元 65 吋大電視 頒獎：台灣大學 陳文章 校 長 摸彩：基金會 李世光 董事長			
16:50-17:10	媒體補訪 冠軍團隊(2 隊)於拍照區發表得獎感言			

決賽辦法

一、決賽時間：2024 年 08 月 21 日 (三) 09:00-17:00

作品組裝：2024 年 08 月 20 日 (二) 15:00-18:00

(一) 8 月 12 日 12:00 前在 LINE / Whatsapp 群組告知是否有此需求

(二) 有需求的團隊，到場後向服務台報到

二、決賽地點：國立臺灣大學綜合體育館 (106 臺北市大安區辛亥路二段 29 號)

三、報到作業：

(一) 時　間：**07:40-08:20 (08:20 以前未完成全員報到的團隊視同棄權)**

(二) 作業事項：

1. 身份驗證(證明身份的學生證、教師證等)
2. 簡報檔更新
   (1) 國際賽 08:30 前到簡報區找工作人員更新。
   (2) 主競賽使用自備的 Notebook 進行簡報，簡報檔若有更新必須提供大會。
3. 資料袋領取：
   (1) 參賽證
   (2) 決賽手冊 (指導教授與隊長各乙本，大會另提供電子檔)
   (3) 人氣獎投票票券 (內附摸彩券)
   (4) 布製手提袋

四、簡報與實作辦法

(一) 簡報順序依編號安排，時間表如下。

(二) 國際賽

每隊 12 分鐘(簡報 6 分鐘+實作問答 6 分鐘)

1. 簡報以 4-6 個團隊為 1 個階段，共分為四個階段，**詳如表列。**
2. 每隊簡報時間為 6 分鐘，每個階段的團隊簡報完成後，評審前往作品展示區進行各團隊的實作、評審提問及技術確認，時間限每個團隊 6 分鐘。
3. 5 分鐘按第一次鈴提示，6 分鐘按兩次長鈴結束簡報。
4. 實作問答時 5 分鐘按第一次鈴提示，6 分鐘按兩次長鈴結束實作問答。
5. 每個階段的團隊實作評審結束，進行下一個階段的團隊的簡報。
6. **簡報語言：英文**
7. 簡報前 15 分鐘到簡報區報到與等候。
8. 評審移動時間不計時。
9. 簡報設備：筆記型電腦乙台（作業系統 Windows 10、文書軟體 Office2019）
   液晶螢幕電視牆（輸入源 HDMI 或 VGA 孔）
   簡報筆、音響設備與麥克風 1 支
   註：如需使用自備的硬體設備，安裝與拆卸時間均列入簡報時間計算。

主競賽

每隊 13 分鐘(簡報與實作 8 分鐘+問答 5 分鐘)

1. 簡報與實作均在作品展區進行，團隊須自備 NB，並提供紙本簡報內容 8 份，每隊簡報加實作時間為 8 分鐘，評審提問 5 分鐘。
2. 7 分鐘按一次鈴，8 分鐘按兩次長鈴結束簡報與實作。
3. 12 分鐘按一次鈴，13 分鐘按兩次長鈴結束評審提問。
4. 依據競賽辦法指導教授可以發言與補充 (但評審盡量指定學生回答)。
5. 前一年有得獎的老師團隊，需請團隊強調作品技術的創新與差異。

10. **簡報語言：中文**

6. 自備筆記型電腦、簡報檔紙本 8 份 (供評審委員聽取簡報時對照使用)
7. 於簡報前 10 分鐘在作品展示區等候

(三) 司儀依據競賽規定主持與控制時間，評審委員依據鈴聲與司儀報幕執行評審作業

(四) 簡報人在申明團隊編號及作品名稱起，大會即開始計時。

(五) 簡報與實作區皆開放各界觀摩。

五、國際賽簡報時間表(每隊 12 分鐘-簡報 6 分鐘+實作問答 6 分鐘)

簡報順序		Briefing 簡報 (6 分鐘)	Demonstration 展示操作問答(6 分鐘)
第一階段 (6 隊)	1	09:10-09:16	09:53-10:30
	2	09:17-09:23	
	3	09:24-09:30	
	4	09:31-09:37	
	5	09:38-09:44	
	6	09:45-09:51	
休息時間		10:30-10:40	
第二階段 (6 隊)	7	10:41-10:47	11:24-12:00
	8	10:48-10:54	
	9	10:55-11:01	
	10	11:02-11:08	
	11	11:09-11:15	
	12	11:16-11:22	
午餐時間		12:00-12:50 (50 分鐘)	
第三階段 (4 隊)	13	12:51-12:57	13:20-13:44
	14	12:58-13:04	
	15	13:05-13:11	
	16	13:12-13:18	
休息時間		13:44-13:49	
第四階段 (4 隊)	17	13:50-13:56	14:19-14:43
	18	13:57-14:03	
	19	14:04-14:10	
	20	14:11-14:17	
成績結算		14:44-15:30(46 分鐘)	
頒獎典禮		15:30-17:00	

六、主競賽簡報時間表(每隊 13 分鐘-簡報與實作 8 分鐘+問答 5 分鐘)

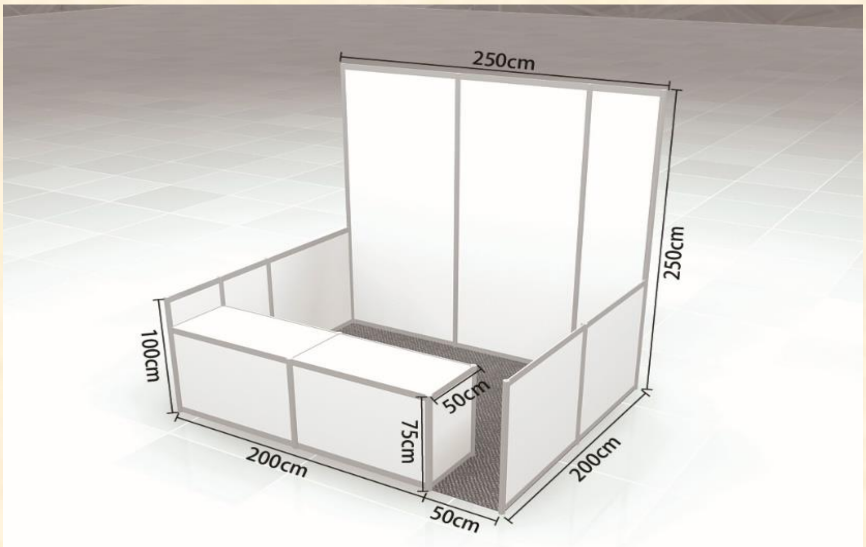
簡報順序		簡報實作(8 分鐘) Briefing & Demonstration	評審問答(5 分鐘) Q & A
第一階段(5 隊)	1	09:10-09:18	09:18-09:23
	2	09:24-09:32	09:32-09:37
	3	09:38-09:46	09:46-09:51
	4	09:52-10:00	10:00-10:05
	5	10:06-10:14	10:14-10:19
休息時間		10:19-10:29	
第二階段(6 隊)	6	10:30-10:38	10:38-10:43
	7	10:44-10:52	10:52-10:57
	8	10:58-11:06	11:06-11:11
	9	11:12-11:20	11:20-11:25
	10	11:26-11:34	11:34-11:39
	11	11:40-11:48	11:48-11:53
午餐時間		11:53-12:40(47 分鐘)	
第三階段(5 隊)	12	12:41-12:49	12:49-12:54
	13	12:55-13:03	13:03-13:08
	14	13:09-13:17	13:17-13:22
	15	13:23-13:31	13:31-13:36
	16	13:37-13:45	13:45-13:50
休息時間		13:50-13:55	
第四階段(4 隊)	17	13:56-14:04	14:04-14:09
	18	14:10-14:18	14:18-14:23
	19	14:24-14:32	14:32-14:37
	20	14:38-14:46	14:46-14:51
成績結算		14:52-15:30(38 分鐘)	
頒獎典禮		15:30-17:00	

七、作品組裝與展示方法

(一) 組裝時間：8 月 20 日(一) 15:00-18:00

8 月 21 日(二) 07:30-簡報與實作前

(二) 展示空間<如圖>：



展示區形式圖(示意)

1. 展示空間 250cm(寬)×200cm(深)×250cm(高)。
2. 桌面 200cm(寬)×50cm(深)× 75cm(高)(※限重 20 公斤)。
3. 作品展示海報 230cm(寬)×150cm(高) (內容由團隊依大會規定提供，並由大會統一輸出)。
4. 請於大會規定或特別許可區域進行操作。

七、決賽評分標準

1. 解決問題與技術價值 40%
2. 創意 25%
3. 技術內涵與可行性 25%
4. 作品完整度 10%

八、獎項、獎金&頒獎人

<table>
<tr><th rowspan="2">名次</th><th rowspan="2">名稱</th><th colspan="3">主競賽</th><th rowspan="2">名稱</th><th colspan="3">國際賽</th></tr>
<tr><th>獎金
(NTD)</th><th>設獎單位</th><th>頒獎人</th><th>獎金
(USD)</th><th>設獎單位</th><th>頒獎人</th></tr>
<tr><td>1</td><td>冠 軍
-富邦淨零科技獎-</td><td>100 萬</td><td>富邦金融控股(股)公司</td><td>蔡明興
董事長</td><td>Champion
冠 軍</td><td>30,793</td><td>TECO Electric & Machinery Co., Ltd.
東元電機(股)公司</td><td>Morris Li
Chairman of Board
東元電機
利明献 董事長</td></tr>
<tr><td>2</td><td>亞 軍
-勇源淨零科技獎-</td><td>60 萬</td><td>勇源教育發展基金會</td><td rowspan="2">陳致遠
執行長</td><td>First Runner-Up
亞 軍</td><td>18,476</td><td>TECO Electric & Machinery Co., Ltd.
東元電機(股)公司</td><td>Tsung-Tsong Wu
Industrial Technology Research Institute (ITRI)
Chairman
財團法人工業技術研究院
吳政忠董事長</td></tr>
<tr><td>3</td><td>季 軍
-勇源永續發展獎-</td><td>40 萬</td><td>勇源教育發展基金會</td><td>Second Runner-Up
季 軍</td><td>12,317</td><td>TECO Electric & Machinery Co., Ltd.
東元電機(股)公司</td><td>Faa-Jeng Lin
National Science and Technology Council (NSTC)
Deputy Minister
國家科學及技術委員會
林法正 政務副主任委員</td></tr>
<tr><td>4</td><td>台灣中油智慧能源獎</td><td>20 萬</td><td>台灣中油(股)公司</td><td>林珂如發言人兼溶劑化學品事業部執行長</td><td>CPC Corporation, Taiwan Smart Energy Award
台灣中油智慧能源獎</td><td>6,159</td><td>CPC Corporation, Taiwan
台灣中油(股)公司</td><td>Angela KoJu Lin
Spokesperson / CEO,Solvent&Chemical Business Divisio
台灣中油(股)公司
林珂如發言人</td></tr>
</table>

5	勝一節能創新獎	20 萬	勝一化工 (股)公司	孫啟發 總經理	NTU-AIAD, Advanced Net Zero Emission Technology Award 前瞻綠能產協零碳希望獎	6,159	NTU AIAD 臺大產學交流發展協會	Su Hui Weng Chairman 臺大產學交流發展協會 翁素蕙理事長
6	和泰前瞻綠能獎	10 萬	和泰集團	陳贊文部長 和泰汽車管理部	Advanced Green Energy Award 前瞻綠能高值獎	3,079	NTU ARC-GMST 台灣大學前瞻綠色材料高值化研究中心	Wen Chang Chen President 國立台灣大學 陳文章校長
7	華南銀行零碳希望獎	10 萬	華南商業銀行(股)公司	黃俊智 總經理	Nan Pao Resins Zero Carbon Vanguard Award 南寶樹脂零碳希望獎	3,079	NAN PAO Resins Chemical Factory Co., Ltd. 南寶樹脂化學工廠(股)公司	Yong-Ching Shen vice president 南寶樹脂化學工廠(股)公司 沈永清副總經理
8 | 20	佳　作	5 萬*13 隊 (65 萬)	東元電機(股)公司		佳　作	1,540*13 隊 (20,020 元)	TECO Electric & Machinery Co., Ltd.	
合計	325 萬元				325 萬元(約 100,000 美元)			
	40 個獎項總獎金 650 萬元整							

說明：

(一) 為確保競賽品質，獎項必要時得從缺。

(二) 獎座於頒獎典禮頒發。

(三) 獎狀於 09/06 前寄送電子版。

(四) 獎金將於決賽兩周內依據各團隊填妥之「獎金支付明細表」(頒獎時提供)，匯入指定帳戶；若為國外團隊，將於確認匯款帳戶後匯入單一指定帳戶。

(五) 佳作獎金統一由隊長於頒獎典禮過後到服務台簽收。

(六) 獎金簽收者依中華民國稅法規定須課 10%稅金，外國人士則須課 20%稅金。

九、注意事項：

(一) 所有參賽成員，均需配戴參賽證，穿著具有**學校或團隊**識別效果之服裝，並攜帶校旗作為布置展區與團隊拍照之用。

(二) 國外的入圍團隊可以以視訊方式參與決賽。

(三) 請攜帶學生證明以備身分驗證。

(四) 請維護大會提供之設備，毀損者需照原價賠償。

(五) 競賽期間宜輕聲細語，並嚴禁干擾競賽進行之言論與行為。

(六) 決賽現場提供飲用水，請自行攜帶環保杯。

(七) 會場禁止吸菸、嚼食口香糖或檳榔。

(八) 隊伍作品展示區由大會統一提供展板及展示櫃(僅供作品展示之用)。

(九) 頒獎典禮後開始撤場，展示海報由各隊自行帶回(鋁桿請交還大會)。

(十) 其他未盡事宜，以現場公告為準。

十一、

(一) 本次競賽增設最佳人氣獎，所有與會來賓、民眾皆可領取投票券參與投票，並獲得東元 65 吋電視的摸彩機會。

(二) 投票時間由 10:00 到 15:20 止，票券可以由服務台領取，每人限投 6 票。

(三) 大會將隨時公布人氣獎的投票現況。

(四) 獎項將於今日 16:40-17:00 於現場公布，並同時進行摸彩。

Final Contest Schedule

<table>
<tr><th>Activity
Time</th><th colspan="2">Agenda</th><th>Details</th><th>International Contest</th><th>Main Contest</th></tr>
<tr><td>07:40-08:20</td><td colspan="2">Check-In</td><td colspan="3">Project Assembly and Exhibition Booth Setup</td></tr>
<tr><td>08:50-09:05</td><td colspan="5">Announcement</td></tr>
<tr><td>09:10-12:53</td><td colspan="2">Briefing and Demonstration – 1st and 2nd Stages</td><td>International Contest:
12 minutes per team
Main Contest:
13 minutes per team</td><td>Master of Ceremonies, Li Tsung-lin</td><td>Master of Ceremonies, Chu Te-yuan</td></tr>
<tr><td>11:53-12:40</td><td colspan="5">Lunch Break</td></tr>
<tr><td>12:40-14:50</td><td colspan="2">Briefing and Demonstration – 3rd and 4th Stages</td><td>International Contest:
12 minutes per team
Main Contest:
13 minutes per team</td><td>Master of Ceremonies, Li Tsung-lin</td><td>Master of Ceremonies, Chu Te-yuan</td></tr>
<tr><td>14:51-15:30</td><td colspan="2">Project Exhibition and Viewing</td><td colspan="3">Juries will calculate scores and generate a winners list.</td></tr>
<tr><td rowspan="2">15:10-15:40</td><td colspan="3">VIP Visit to International Contest Projects</td><td colspan="2">Guided Tour by National Taiwan University President Chen Wen-chang</td></tr>
<tr><td colspan="3">VIP Visit to Main Contest Projects</td><td colspan="2">Guided Tour by TECO Electric & Machinery Co., Ltd. General Manager Thomas Fann</td></tr>
<tr><td rowspan="4">15:40-16:00</td><td colspan="2">Arrival of President and Distinguished Guests</td><td>Group Photo</td><td colspan="2">Master of Ceremonies, Li Tsung-lin</td></tr>
<tr><td colspan="2">Contest Introduction</td><td colspan="3">Video Presentation</td></tr>
<tr><td colspan="2">Introduction of Distinguished Guests</td><td></td><td colspan="2">Master of Ceremonies, Li Tsung-lin</td></tr>
<tr><td colspan="2">Opening Remarks by the Organizing Committee</td><td colspan="3">Speech by Mr. Lee Chih-kung, Chairman of TECO Technology Foundation
Speech by Mr. Chen Wen-chang, President of National Taiwan University</td></tr>
<tr><td rowspan="11">16:00-16:40</td><td rowspan="11">Award Ceremony</td><td rowspan="6">Main</td><td>華南銀行零碳希望獎</td><td colspan="2">華南銀行 黃俊智 總經理</td></tr>
<tr><td>和泰前瞻綠能獎</td><td colspan="2">和泰集團 陳贊文 部　長</td></tr>
<tr><td>勝一節能創新獎</td><td colspan="2">勝一化工 孫啟發 總經理</td></tr>
<tr><td>台灣中油智慧能源獎</td><td colspan="2">台灣中油 林珂如 執行長</td></tr>
<tr><td>季　軍 -勇源永續發展獎-</td><td colspan="2" rowspan="2">勇源基金會 陳致遠 執行長</td></tr>
<tr><td>亞　軍 -勇源淨零科技獎-</td></tr>
<tr><td rowspan="5">Int'l</td><td>Nan Pao Resins Zero Carbon Vanguard Award</td><td colspan="2">Yong-Ching Shen, Vice President, NAN PAO Resins Chemical Factory Co., Ltd.</td></tr>
<tr><td>Advanced Green Energy Award</td><td colspan="2">Chen Wen-chang, President, NTU ARC-GMST</td></tr>
<tr><td>NTU-AIAD, Advanced Net Zero Emission Technology Award</td><td colspan="2">Su Hui Weng, Chairman, NTU AIAD</td></tr>
<tr><td>CPC Corporation, Taiwan Smart Energy Award</td><td colspan="2">Angela KoJu Lin Spokesperson / CEO, Solvent & Chemical Business Divisio</td></tr>
<tr><td>Second Runner-Up</td><td colspan="2">Faa-Jeng Lin</td></tr>
</table>

				National Science and Technology Council (NSTC) Deputy Minister
			First Runner-Up	Tsung-Tsong Wu, Chairman, Industrial Technology Research Institute (ITRI)
		Main	冠　軍(富邦淨零科技獎)	富邦金控 蔡明興 董事長
		Int’l	Champion	Morris Li, Chairman, TECO Electric & Machinery Co., Ltd.
	Photo Session with Champion Team, Award Presenter, and Awarding Organization			Chen Wen-chang, President of NTU Lee Chih-kung, Chairman, TECO Technology Foundation
16:40-16:45	Photo Session with Winning Teams and President			
16:45-16:50	Announcement of Popularity Award Winner, Raffle for TECO 65-inch TV Award Presentation: Chen Wen-chang, President of NTU Raffle: Lee Chih-kung, Chairman, TECO Technology Foundation			
16:50-17:10	Media Follow-up Interviews Acceptance Speech			

Final Contest Check-In Notice

I. Final Contest Time: August 21, 2024 (Wednesday), 09:00-17:00

Project Assembly： August 20, 2024 (Tuesday) 15:00-18:00

A. Inform the main message group if there is a need for assembly before 12:00 on August 12.

B. Teams with assembly needs should check in at the service desk upon arrival.

II. Final Contest Venue: National Taiwan University Gymnasium (No. 29, Sec. 2, Xinhai Rd., Da'an Dist., Taipei City 106, Taiwan)

III. Check-In Procedures:

A. Time: **07:40-08:20 (Teams that do not complete check-in for all members by 08:20 will be considered as forfeited)**

B. Procedures:

1). Identity Verification (Student ID, Teacher ID, etc. to prove identity)

2). Presentation (Briefing) File Updates

(1) For the International Contest: Please go to the designated presentation area to find staff before 08:30 for updates.

(2) For the Main Contest: Please bring your own laptop for presentations. If there are any updates to the presentation files, please provide them to the organizer.

3). Materials Bag Collection:

(1) Participant Badge

(2) Final Contest Manual (one copy each for the advisor and team leader; an electronic version will also be provided)

(3) Popularity Award Voting Ticket (includes a raffle ticket)

(4) Tote Bag

IV. Briefing and Demonstration Procedures:

A. The briefing order will follow the assigned numbers. The detailed schedule is as the following table.

B. **International Contest-12 minutes per team (6 minutes briefing + 6 minutes demonstration and Q&A)**

1. Briefings will be divided into four stages, with 4-6 teams per stage, **as detailed in the table**.
2. Each team will have 6 minutes for their briefing. After each stage, the juries will proceed to the exhibition area for evaluation.
3. The first bell will ring once at the 5-minute mark and twice at the 6-minute mark to signal the end of the briefing.

4. For demonstration and Q&A, the bell will ring once at the 5-minute mark and twice at the 6-minute mark to signal the end of the Q&A.
5. After jurying is completed for each stage, the next stage will begin.
6. **Presentation language: English**
7. Each team must check in and wait at the presentation area 15 minutes before their scheduled presentation.
8. The time for the juries to move between stages is not counted.
9. Equipment Provided by the Organizer: One laptop (pre-installed with Windows 10 & Microsoft Office 2019), an LCD TV wall (with HDMI or VGA input), a presentation clicker, audio equipment, and one microphone.
10. Note: If teams need to use their own hardware, the setup and removal time will be included in the presentation time.

Main Contest-13 minutes per team (8 minutes briefing and demonstration + 5 minutes Q&A)

1. Both the briefing and demonstration will be conducted in the exhibition area. Teams must bring their own laptops and provide 8 paper copies of their briefing content. Each team will have 8 minutes for briefing and demonstration, followed by 5 minutes of Q&A from the juries.
2. A bell will ring once at the 7-minute mark and twice at the 8-minute mark to signal the end of the briefing and demonstration.
3. A bell will ring once at the 12-minute mark and twice at the 13-minute mark to signal the end of the Q&A.
4. According to the Contest rules, the supervising professor can speak and supplement (though juries will try to designate students to answer as much as possible).
5. Teams with supervising instructors that have won awards in the previous year are required to highlight the technical innovation and differences of their projects.
6. **Presentation language: Mandarin**
7. Teams must bring their own laptops and provide 8 paper copies of the briefing content (for juries to refer to during the presentation).
8. Each team must standby at the demonstration area 10 minutes before their scheduled presentation.

C. The Master of Ceremonies (emcee) will host and control the time according to the Contest rules. The juries will conduct the judging according to the bell and the emcee's announcement.

D. The timer will start as soon as the presenter states the team number and project name.

E. Both the briefing and demonstration areas are open for public observation.

V. International Contest Presentation Schedule (12 minutes per team – 6 minutes briefing + 6 minutes Q&A and demonstration)

Presentation Order		Briefing (6 minutes)	Demonstration and Q&A (6 minutes)
Stage 1 **(6 teams)**	1	09:10-09:16	09:53-10:30
	2	09:17-09:23	
	3	09:24-09:30	
	4	09:31-09:37	
	5	09:38-09:44	
	6	09:45-09:51	
Break time		**10:30-10:40**	
Stage 2 **(6 teams)**	7	10:41-10:47	11:24-12:00
	8	10:48-10:54	
	9	10:55-11:01	
	10	11:02-11:08	
	11	11:09-11:15	
	12	11:16-11:22	
Lunch break		**12:00-12:50 (50 minutes)**	
Stage 3 **(4 teams)**	13	12:51-12:57	13:20-13:44
	14	12:58-13:04	
	15	13:05-13:11	
	16	13:12-13:18	
Break time		**13:44-13:49**	
Stage 4 **(4 teams)**	17	13:50-13:56	14:19-14:43
	18	13:57-14:03	
	19	14:04-14:10	
	20	14:11-14:17	
Score Calculation		**14:44-15:30 (46 minutes)**	
Award Ceremony		**15:30-17:00**	

VI. **Main Contest** Presentation Schedule (13 minutes per team – 8 minutes for briefing and demonstration + 5 minutes for Q&A)

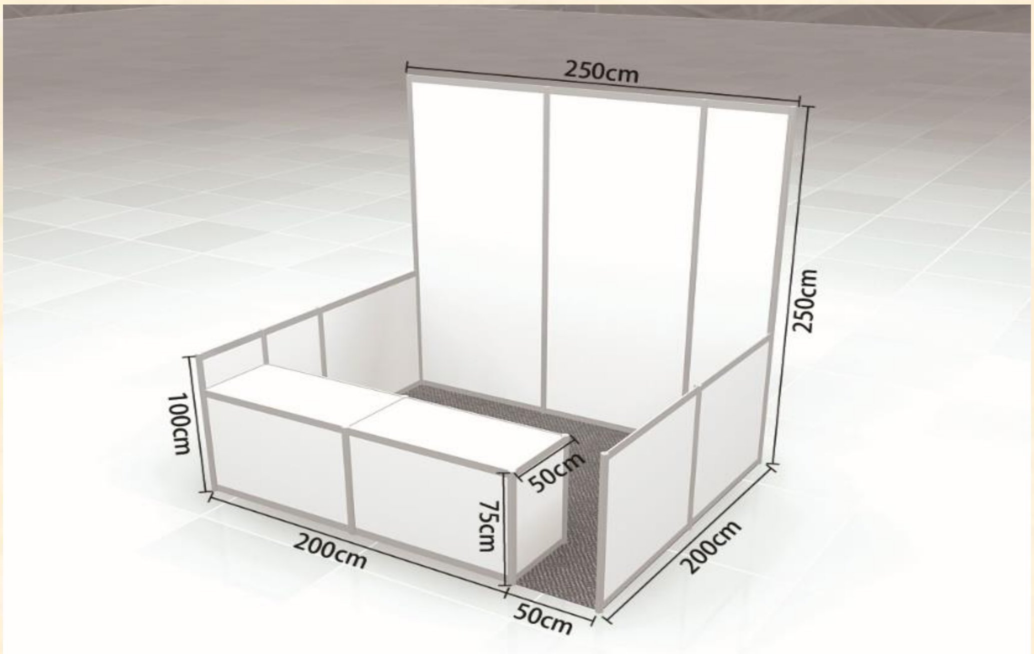
Presentation Order		Briefing & Demonstration (8 minutes)	Q & A (5 minutes)
Stage 1 (5 teams)	1	09:10-09:18	09:18-09:23
	2	09:24-09:32	09:32-09:37
	3	09:38-09:46	09:46-09:51
	4	09:52-10:00	10:00-10:05
	5	10:06-10:14	10:14-10:19
Break time		**10:19-10:29**	
Stage 2 (6 teams)	6	10:30-10:38	10:38-10:43
	7	10:44-10:52	10:52-10:57
	8	10:58-11:06	11:06-11:11
	9	11:12-11:20	11:20-11:25
	10	11:26-11:34	11:34-11:39
	11	11:40-11:48	11:48-11:53
Lunch break		**11:53-12:40 (47 minutes)**	
Stage 3 (5 teams)	12	12:41-12:49	12:49-12:54
	13	12:55-13:03	13:03-13:08
	14	13:09-13:17	13:17-13:22
	15	13:23-13:31	13:31-13:36
	16	13:37-13:45	13:45-13:50
Break time		**13:50-13:55**	
Stage 4 (4 teams)	17	13:56-14:04	14:04-14:09
	18	14:10-14:18	14:18-14:23
	19	14:24-14:32	14:32-14:37
	20	14:38-14:46	14:46-14:51
Score Calculation		**14:52-15:30 (38 minutes)**	
Award Ceremony		**15:30-17:00**	

VII. Work Assembly and Exhibition Methods

A. Assembly Time:

- August 20 (Monday) 15:00-18:00
- August 21 (Tuesday) 07:40 until before the briefing and demonstration

B. Exhibition Space (as shown):



Schematic diagram of the exhibition booth

1. Exhibition booth space: 250cm (width) × 200cm (depth) × 250cm (height)
2. Table: 200cm (width) × 50cm (depth) × 75cm (height) (※maximum weight limit 20 kg)
3. Project display poster: 230cm (width) × 150cm (height)
   (Content to be created by the team according to the conference regulations and will be uniformly printed and arranged by the conference).
4. Please operate only within the specified or specially permitted areas of the conference.

VIII. Final Contest Scoring Criteria

1. Problem Solving and Technical Value: 40%
2. Creativity: 25%
3. Technical Content and Feasibility: 25%
4. Completeness of the Work: 10%

IX Awards and presenters

Order	Title	Main Contest			Title	International Contest		
		Prize (NTD)	Sponsor	Presenter		Prize (USD)	Sponsor	Presenter
1	冠 軍 -富邦淨零科技獎-	100 萬	富邦金融控股(股)公司	蔡明興 董事長	Champion	30,793	TECO Electric & Machinery Co., Ltd.	Morris Li Chairman of Board
2	亞 軍 -勇源淨零科技獎-	60 萬	勇源教育發展基金會	陳致遠 執行長	First Runner-Up	18,476	TECO Electric & Machinery Co., Ltd.	Tsung-Tsong Wu Industrial Technology Research Institute (ITRI) Chairman
3	季 軍 -勇源永續發展獎-	40 萬	勇源教育發展基金會		Second Runner-Up	12,317	TECO Electric & Machinery Co., Ltd.	Faa-Jeng Lin National Science and Technology Council (NSTC) Deputy Minister
4	台灣中油智慧能源獎	20 萬	台灣中油(股)公司	林珂如發言人兼溶劑化學品事業部執行長	CPC Corporation, Taiwan Smart Energy Award	6,159	CPC Corporation, Taiwan	Angela KoJu Lin Spokesperson / CEO,Solvent&Chemical Business Divisio
5	勝一節能創新獎	20 萬	勝一化工 (股)公司	孫啟發 總經理	NTU-AIAD, Advanced Net Zero Emission Technology Awar	6,159	NTU AIAD	Su Hui Weng Chairman

6	和泰前瞻綠能獎	10 萬	和泰集團	陳贊文部長 和泰汽車管 理部	Advanced Green Energy Award	3,079	NTU ARC-GMST	Wen Chang Chen President
7	華南銀行零碳 希望獎	10 萬	華南商業銀行 (股)公司	黃俊智 總經理	Nan Pao Resins Zero Carbon Vanguard Award	3,079	NAN PAO Resins Chemical Factory Co., Ltd.	Yong-Ching Shen vice president
8 | 20	佳　作	5 萬*13 隊 (65 萬)	東元電機(股)公司		Excellence	1,540*13 teams (20,020)	**TECO Electric & Machinery Co., Ltd.**	
Total	325 萬元				**NTD 3,250,000 (**About USD 100,000)			
	40 awards with a total prize money of NTD 6.5 million dollars.							

Notes:

(1) To ensure the quality of the Contest, awards may be vacant if necessary.

(2) Trophies will be awarded at the award ceremony.

(3) Certificates will be sent electronically before September 6.

(4) Prize money will be transferred to the designated accounts within two weeks after the final Contest, based on the “Prize Payment Details Form” completed by each team (provided at the award ceremony). For international teams, the prize money will be transferred to a single designated account after the account details are confirmed.

(5) Honorable Mention prize money must be signed for and collected by the team leader at the service desk after the award ceremony.

(6) Prize recipients are subject to a 10% tax according to the tax laws of Taiwan (R.O.C.); foreign nationals are subject to a 20% tax.

Best Popularity Award

An additional award will be given for the best popularity. Voting ticket and a chance to win TECO′ s 65-inch TV are provided to all attendees.

Voting from 10:00 to 15:20, tickets are given from service center, six tickets per person.

The organizer will announce the current results at any time.

Best Popularity Award and lottery will announce at 16:40-17:00.

評審委員名錄 Jury Members

類別 Category		姓名 Name	現職 Title
總召集人 General Convener		陳文章 Wen-Chang Chen	國立臺灣大學 校長 President of National Taiwan University
國際賽 International	召集人 Convener	蘇芳慶 Fong-Chin Su	國立成功大學生物醫學工程學系講座教授 Chair Professor, Department of Biomedical Engineering, NCKU
	委 員 Jury Members	童遷祥 Alex Tong	鼎唐能源科技股份有限公司執行長 CEO, Green Cellulosity Corporation
		賴炎生 Yen Shin Lai	國立臺北科技大學電機工程系講座教授 Chair Professor, Department of Electrical Engineering, NTUT
		高志明 Chih-Ming Kao	國立中山大學環境工程研究所西灣講座教授 Chair Professor, Institute of Environmental Engineering, NSYSU
		陳志臣 Jyh-Chen Chen	國立中央大學機械工程學系講座教授 Chair Professor, Department of Mechanical Engineering, NCU
		蔣本基 Pen-Chi Chiang	國立臺灣大學環境工程學研究所終身特聘教授 Lifetime Distinguished Professor, Graduate Institute of Environmental Engineering, NTU
		金光恩 Kwang-Un Clarence King	東元電機(股)公司產銷中心協理 TECO Electric & Machinery Co., Ltd.
主競賽 Main	召集人 Convener	林一平 Yi-bing Lin	國立陽明交通大學資訊工程學系終身講座教授 Lifetime Chair Professor, Department of Computer Science, NYCU
	委 員 Jury Members	談駿嵩 Chung-Sung Tan	國立清華大學化工系榮譽教授 Honorary Professor, Department of Chemical Engineering, NTHU
		林法正 Faa-Jeng Lin	國家實驗研究院 院長 President, National Applied Research Laboratories
		李宗銘 Tzong Ming Lee	財團法人工業技術研究院材化所所長 General Director, Material and Chemical Research Laboratories, ITRI
		周至宏 Jyh-Horng Chou	國立高雄科技大學電機工程系 講座教授 Chair Professor, Department of Electrical Engineering, NKUST
		陳誠亮 Cheng-Liang Chen	國立臺灣大學化學工程學系教授 Professor, Department of Chemical Engineering, NTU
		何昆耀 Kwun-Yao HO	東元電機(股)公司綜合研究所所長 General Director, General Research Laboratory, TECO Electric & Machinery Co., Ltd.

The Finalists of International Contest

No.	Work Title	Position	Name	School	Department
INTL01	Superhydrophobic Metal-Organic Framework (MOF) Sponge Composite for Oil-Water Separation	Advisor	林嘉和	National Taiwan Normal University (Taiwan, R.O.C.)	Department of Chemistry
		Student	陳佳樂		
		Student	王昱順		
		Student	劉鴻恩		
INTL02	Application of a New High-Gain Power Converter in Next-Generation Renewable Energy Systems	Advisor	Liu Hwa-Dong	National Taiwan Normal University / National Taiwan University of Science and Technology (Taiwan, R.O.C.)	Undergraduate Program of Vehicle and Energy Engineering / Department of Electrical Engineering
		Advisor	Lin Chang-Hua		
		Student	Ul Munieeb Mosaib		
		Student	Sahito Ahmed Tauseeque		
		Student	Shih Jyun-Wei		
		Student	Chen Wei-Yu		
INTL03	Advanced Carbon Capture and Elimination Process Technology using Membrane Engineering (ACCEPT-ME)	Advisor	Kang Dun Yen	National Taiwan University (Taiwan, R.O.C.)	Department of Chemical Engineering
		Student	Wu Po Chun		
		Student	Lee Sher Ling		
		Student	Yu Yuan Chen		
		Student	Chang Shou Feng		

No.	Work Title	Position	Name	School	Department
INTL04	Low-Cost Energy-Efficient Atmospheric-Pressure Plasma Jet Processed NiCo-Metalorganic Framework Electrocatalyst in Anion Exchange Membrane Water Electrolysis Module	Advisor	陳建彰	National Taiwan University / National Taiwan University of Science and Technology (Taiwan, R.O.C.)	Institute of Applied Mechanics / Graduate Institute of Photonics and Optoelectronics / Department of Chemical Engineering / Graduate School of Advanced Technology, Program for Nanoengineering and Nanoscience
		Advisor	陳奕君		
		Advisor	王孟菊		
		Student	普智暉		
		Student	余碩恩		
		Student	闕振宸		
		Student	陳奇松		
		Student	洪柏彥		
		Student	吳幸真		
		Student	謝尚霖		
		Student	董芮妤		
INTL05	Integrating a novel Coastal Wave Energy Converter and Carbon Negative Cement for Net Zero	Advisor	Ou Ting-Chia	National Cheng Kung University (Taiwan, R.O.C.) / Leiden University & Delft University of Technology / National Tsing Hua University (Taiwan, R.O.C.)	Program on Smart and Sustainable Manufacturing / Industrial Ecology Master's Program / Bachelor of Science / Department of Civil Engineering
		Student	Ju Zhi-Chin		
		Student	Chen Yu-Tung		
		Student	Chen Shu-Er		

No.	Work Title	Position	Name	School	Department
INTL06	Green and Advanced Magnesium-based Hydrogen Storage Alloy	Advisor	顏鴻威	National Taiwan University (Taiwan, R.O.C.)	Department of Materials Science and Engineering / Graduate School of Advanced Technology, Program for Semiconductor Devices, Materials, and Hetero-integration
		Advisor	謝宗霖		
		Student	Lin Ting-Si		
		Student	Hung Hao-Chun		
		Student	Chen Bo Xian		
		Student	Hou Yu Ching		
		Student	Wang Yu Hsiang		
INTL07	EcoSphere: A Model for Sustainable and Effective Learning Environment	Advisor	Kok Sum Ng	Sunway University (Malaysia)	School of Engineering and Technology / Department of Art, Design and Media, School of Arts
		Advisor	Angela Siew Hoong Lee		
		Advisor	Chew Xiang Fu		
		Advisor	Hock Kuen Foong		
		Student	Jen Looi Tee		
		Student	Deaberniswarar Sharmaa		
		Student	May Mun Yi Yeap		
		Student	Jonathan Jared Ignacio		
		Student	Chiao Pin Tan		
		Student	Willion Wei Yen Yap		
		Student	Jason Kow		

No.	Work Title	Position	Name	School	Department
INTL08	Novel process design and validation for decreasing CO2 emission from cement production decarbonization	Advisor	吳　煒	National Cheng Kung University (Taiwan, R.O.C.)	Department of Chemical Engineering / Department of Civil Engineering
		Advisor	賴啟銘		
		Student	吳紀昀		
		Student	張宸語		
		Student	Mazumdar Debayan		
		Student	曾慶豪		
INTL09	Next-Generation Redox-Mediated Bipolar Membrane Electrodialysis: Simultaneous Seawater Desalination and Carbon Capture	Advisor	侯嘉洪	National Taiwan University (Taiwan, R.O.C.)	Graduate Institute of Environmental Engineering
		Student	吳旻臻		
		Student	張睿耀		
		Student	高毓彗		
		Student	王柏硯		
		Student	陳怡瑋		
INTL10	A novel up-scaling process of a photoelectrochemical system with H2 generation for real saline sewage treatment: taking pioneering steps towards net zero wastewater treatment technology	Advisor	Irene Man Chi Lo	The Hong Kong University of Science and Technology (Hong Kong)	Department of Civil and Environmental Engineering
		Advisor	Zexiao Zheng		
		Student	Taoran Dong		
		Student	Hoi Kit Justin Man		
		Student	Cheuk Wai Lung		

No.	Work Title	Position	Name	School	Department
INTL11	E-Sense Power	Advisor	Wang Huai	Aalborg University (Denmark)	AAU Energy
		Student	Wei Xing		
		Student	Zhang Yichi		
		Student	Liu Yongjie		
		Student	Yao Bo		
		Student	Liu Jiahong		
INTL12	A rechargeable zinc-air battery enabled by a solid hydrogel electrolyte in both atmospheric and low-temperature conditions	Advisor	劉大中	National Yang Ming Chiao Tung University (Taiwan, R.O.C.)	Department of Biomedical Engineering
		Student	楊融昊		
		Student	徐晨軒		
		Student	翁永承		
		Student	林泓証		
		Student	何紹圻		
INTL13	The Decarbonizer: A Comprehensive Solution for Waste Reduction and Hydrogen Production	Advisor	Wei Cheng Wang	National Cheng Kung University / National Sun Yat Sen University (Taiwan, R.O.C.)	Department of Aeronautics and Astronautics / Mechanical and Electro-Mechanical Engineering / International Degree Program on Energy Engineering
		Student	Rusdan Aditya Aji Nugroho		
		Student	林明叡		
		Student	Muhammad Azmi		
		Student	鄭　宇		

No.	Work Title	Position	Name	School	Department
INTL14	Seaweed Afforestation: Unlocking the Ocean’s Potential for Carbon Sequestration	Advisor	任昊佳	National Taiwan University / Academia Sinica / National Taiwan Ocean University (Taiwan, R.O.C.)	Department of Geosciences / Research Center for Environmental Changes / Center of Excellence for the Oceans / Institute of Oceanography
		Advisor	何東垣		
		Advisor	張睿昇		
		Advisor	Stephens Brandon		
		Student	Tan Carel		
		Student	蔡李人誼		
		Student	嚴語晨		
INTL15	Ultrahigh Efficiency Bidirectional DC-DC Converter for Energy Storage and Super Charger Applications	Advisor	Jih-Sheng Lai	Virginia Polytechnic Institute and State University (US)	Electrical and Computer Engineering / Mechanical Engineering
		Student	Bryan Gutierrez		
		Student	Hsin-Che Hsieh		
		Student	Ching-Yao Liu		
		Student	Ganesh Rai		
INTL16	EcoAlgae	Advisor	Tharushi Prabha Keerthisinghe	University of Moratuwa (Sri Lanka)	Department of Chemical and Process Engineering
		Student	Isumi De Silva		
		Student	Januth Liyanage		
		Student	Janitha Dissanayake		
		Student	Gavin Senaratne		

No.	Work Title	Position	Name	School	Department
INTL17	Sao Paulo Net Zero Design and Net Zero Emission Sustainable Public Library	Advisor	Ardiyansyah Yatim	University of Indonesia (Indonesia)	Mechanical Engineering / Architecture
		Advisor	Ova Candra Dewi		
		Student	Leonardo Dillon		
		Student	Alexander Ganesh Aji Dewanto		
		Student	Heidy Sekardini		
		Student	Amar Falah Riyanto		
		Student	Farras Hafizh Al Farisi		
		Student	Vynna Alviolina Indriyana		
INTL18	Bromeliad Library: Achieving Net Zero Operation in São Paulo through Energy-Efficient Library with Clay Facades, Fog Catchers, and Sustainable Mechanical Systems	Advisor	Ardiansyah Yatim	University of Indonesia (Indonesia)	Mechanical Engineering / Architecture
		Advisor	Mikhta Farid Alkadri		
		Student	Bimantyo Ganggas Fadhil Ihsani		
		Student	Miguel Bintang Samuel		
		Student	Alfian Febrianto		
		Student	Muflikh Kas Yudamaulana		
		Student	Alya Widha Aurellia		
		Student	Risma Fitriyanti		

No.	Work Title	Position	Name	School	Department
INTL19	A Solution for Sustainable Future: Design and Feasibility Analysis of Chemicals-based International Renewable Energy Supply Chain	Advisor	Chen Cheng-Liang	National Taiwan University (Taiwan, R.O.C.)	Chemical Engineering
		Student	Ong Chong Wei		
		Student	Lien Sheng-Chi		
		Student	Chang Hao-Chu		
		Student	Wang Wei-De		
INTL20	Nanomaterial-driven ‘green-heat’ generation for CO2-free space-heating and water-desalination	Advisor	Sandip Kumar Saha	Indian Institute of Technology Bombay (India)	Mechanical Engineering / Chemistry / Energy Science and Engineering
		Advisor	Chandramouli Subramaniam		
		Student	Anuj Bangad		
		Student	Nikita Vasudev Chitre		
		Student	Dipin Thacharakkal		

主競賽參賽團隊名冊

編　號	作　品　名　稱	職　稱	姓　名	學　校	系　所
MAIN 01	高效捕捉、轉質再利用及碳材開發技術	指導教授	陳維新	國立成功大學	航空太空工程學系
		指導教授	李冠廷	東海大學	化學工程與材料工程學系
		指導教授	游承修	國立臺灣科技大學	化學工程系
		指導教授	張家欽	國立臺南大學	綠色能源科技學系
		指導教授	陳俊延	國立成功大學	生物科技中心
		指導教授	曾堯宣	國立臺灣科技大學	化學工程系
		隊　長	張庭瑜	東海大學	化學工程與材料工程學系
		隊　員	林哲安	國立成功大學	國際能源碩士學位學程
		隊　員	林羿同		
		隊　員	黃光峻	國立臺灣科技大學	化學工程系
MAIN 02	高產率硝酸鹽產綠氨之可產業化膜電極模組-邁向綠氨經濟與碳捕捉之路	指導教授	郭東昊	國立臺灣科技大學	材料科學與工程系暨能源永續科技研究所
		隊　長	Ha Quoc Nam	國立臺灣科技大學	材料科學與工程系
		隊　員	詹育展	國立臺灣科技大學	能源永續科技研究所
		隊　員	劉冠甫	國立臺灣科技大學	材料科學與工程系

編　號	作　品　名　稱	職　稱	姓　名	學　校	系　所
MAIN 03	從廢棄到再生：利用回收再生鈣實現碳捕獲與資源化	指導教授	盧明俊	國立中興大學	環境工程學系
		隊　長	黃澼葳		
		隊　員	陳文榆		
		隊　員	呂博揚		
		隊　員	侯宣羽		
MAIN 04	四重廢熱回收	指導教授	陳維新	國立成功大學	航空太空工程學系
		指導教授	池易楷	國立臺南大學	綠色能源科技學系
		指導教授	謝瑞青	國立勤益科技大學	機械工程系
		指導教授	汪俊延	國立中興大學	材料科學與工程學系
		指導教授	林弘萍	國立成功大學	化學系
		隊　長	梁品鈞	國立成功大學	航空太空工程學系
		隊　員	王志翔		
		隊　員	郭峻宇		
		隊　員	郭尚融	國立臺南大學	綠色能源科技學系
MAIN 05	基於工業 4.2-綠色智慧製造 (I4.2-GiM)框架之節能減碳調節 (ESCRA)系統	指導教授	丁　顥	國立成功大學	製造資訊與系統研究所
		指導教授	陳俊延		生物科技中心
		指導教授	鄭芳田		智慧製造研究中心
		隊　長	范裕慈		製造資訊與系統研究所
		隊　員	黃容羽		環境工程學系

編　號	作　品　名　稱	職　稱	姓　名	學　校	系　所
MAIN 06	合成低碳雙金屬催化劑處理有機廢水之節能與創新應用	指導教授	盧明俊	國立中興大學	環境工程學系
		隊　長	陳映妤		
		隊　員	陳政曜		
		隊　員	李驊恩		
MAIN 07	有害廢棄物之高值化再利用	指導教授	吳威德	國立中興大學	材料科學與工程學系
		指導教授	林啓明		工業與智慧科技學位學程
		指導教授	劉凡瑋		半導體與綠色科技學位學程
		指導教授	林家吟		循環經濟研究學院半導體與綠色科技學程
		隊　長	羅紹峰		材料科學與工程學系
		隊　員	沈峻名		
		隊　員	蔡啓春		
		隊　員	洪右任		
		隊　員	陳鈺澤		工業與智慧科技學位學程
		隊　員	莊尉程		
		隊　員	李珈瑜		循環經濟研究學院半導體與綠色科技學程
		隊　員	蘇俊安		半導體與綠色科技學位學程
MAIN 08	低能耗之磁浮飛輪儲能系統	指導教授	陳世樂	國立中正大學	機械工程學系
		隊　長	林敬翔		
		隊　員	王聖鈞		
		隊　員	魏碩池		

編　號	作　品　名　稱	職　稱	姓　名	學　校	系　所
MAIN 09	綠色材料應用於能源技術開發:光熱海綿達成綠電淨水的生產	指導教授	童國倫	國立臺灣大學	化學工程學所
		隊　長	葉佾叡		
		隊　員	陳劭宇		
		隊　員	林佳宏	國立臺灣科技大學	化學工程所
MAIN 10	稀有磁理 - 創新低碳回收純化技術	指導教授	賴志煌	國立清華大學	材料科學工程學系
		隊　長	羅韶奇		
		隊　員	林淨因		
		隊　員	邱廷煥		
MAIN 11	實現淨零碳排：打造生物廢水處理技術革新突破	指導教授	吳哲宏	國立成功大學	環境工程學系
		隊　長	林宜庭		
		隊　員	馮禮君		
		隊　員	邵勇先		
		隊　員	莊函音		
		隊　員	陳杉樺		
MAIN 12	PGME 製程鹼性廢液嗜鹼性菌族群生物處理及負碳效益評估	指導教授	吳向宸	國立中興大學	環境工程學系
		隊　長	陳建丞		
		隊　員	鄭宇閑		
		隊　員	曾苡禎		

編　號	作　品　名　稱	職　稱	姓　名	學　校	系　所
MAIN 13	全自動產水 太陽光驅動產水自供電水凝膠之循環應用	指導教授	劉振良	國立臺灣大學	材料科學與工程學系
		指導教授	康敦彥		化學工程學系
		指導教授	羅世強		材料科學與工程學系
		隊　長	林政遠		
		隊　員	王鈺皓		
		隊　員	謝子云		
		隊　員	蕭力維		化學工程學系
		隊　員	林羿萱		
MAIN 14	金屬燃燒應用之淨零碳排動力系統	指導教授	陳文立	國立成功大學	航太工程學系
		指導教授	李約亨		
		隊　長	林伯鴻		
		隊　員	王彥儒		
		隊　員	Le Minh Tam		
		隊　員	李苑萱		工程科學系
MAIN 15	多元製程開發高效產氫整合一體化系統	指導教授	王冠文	國立中央大學	材料科學與工程研究所
		指導教授	洪緯璿		
		指導教授	李勝偉		
		隊　長	張家語		
		隊　員	邱玟溢		
		隊　員	邱奕嘉		
		隊　員	許育逢		

編　號	作　品　名　稱	職　稱	姓　名	學　校	系　所
MAIN 16	自主材料開發之硫化物固態電解質運用於鋰金屬電池	指導教授	鍾昇恒	國立成功大學	材料科學及工程學系
		隊　長	郭昱均		
		隊　員	吳承哲		
		隊　員	詹子靚		
		隊　員	楊世綸		
		隊　員	陳奕維		
MAIN 17	電驅動酸鹼震盪碳捕捉再利用	指導教授	潘述元	國立臺灣大學	生物環境系統工程學系
		指導教授	曾渤之		
		隊　長	林育誼		
		隊　員	鄭又綺		
		隊　員	陳心儀		
		隊　員	葉晉豪		
MAIN 18	奈米纖維素混摻鈣鈦礦形成新穎奈米纖維膜以提升光學性質及熱穩定性	指導教授	郭霽慶	國立臺北科技大學	分子科學與工程系
		隊　長	徐紫軒		
		隊　員	林鎧薇		
		隊　員	吳靖揚		

編　號	作　品　名　稱	職　稱	姓　名	學　校	系　所
MAIN 19	開發全水解可回收生物性黏結劑及電解質在鋰電池的應用	指導教授	吳孟真	國立中興大學	理學院科教中心
		指導教授	紀柏葦	中原大學	機械工程學系
		隊　長	陳彥睿	國立清華大學	工程與系統科學系所
		隊　員	蘇毓軒		
		隊　員	鐘晉毅		
		隊　員	陳偉銘		
MAIN 20	資能協同於去化污泥之綠色隔熱材與綠智雙軸永續應用	指導教授	陳立憲	國立臺北科技大學	土木工程系
		指導教授	陳清祺		能源與冷凍空調工程系
		隊　長	郭彥廷		土木工程系
		隊　員	康宇翔		能源與冷凍空調工程系
		隊　員	賴建豪		
		隊　員	曾子軒		電機工程系

作 品 介 紹 ｜ 國 際 賽

Project Introduction

<International Contest>

No. ： **INTL 01**

Works ： Superhydrophobic Metal-Organic Framework (MOF) Sponge Composite for Oil-Water Separation

School ： National Taiwan Normal University

Department ： Chemistry

Advisor ： Chia-Her Lin **/** +886-9-1067 4528 **/** chiaher@ntnu.edu.tw

Leader ： Jia-Le Chen **/** +886-9-3865 9796 **/** 2362157520le@gmail.com

Member ： Yu-Shun Wang　Hung-En Liu

ITEM	Description
Introduction of Team	Our team is from the Department of Chemistry at National Taiwan Normal University, led by Professor Chia-Her Lin. We focus on the green synthesis and structural characterization of novel Metal-Organic Frameworks (MOFs), researching their applications as eco-friendly functional materials, with a commitment to promoting environmental protection.
Creation Motive (Problem-solving and technical value)	This research develops a superhydrophobic material for efficient oil-water separation, solving the water pollution from oil spills. Metal-organic frameworks (MOFs) are valuable due to their high surface area and design flexibility, but hydrophobic modifications can reduce their porosity. To address this, the study uses a hydrophilic melamine sponge as a substrate, modifying it to create a superhydrophobic sponge (AlTz-68-C18@Sponge) with excellent separation performance, offering a promising solution for marine oil spills.
Research Process	The study selectively modified the outer surface of MOF systems with internal lattice rearrangement to construct superhydrophobic MOFs. By performing a click reaction with hydrophobic alkyl chains on the surface of defect-rich porous material AlTz-53, followed by internal framework rearrangement during activation treatment, the internal porosity and crystallinity of the material were significantly enhanced.
Brief of Work (Creativity/Technical content and feasibility)	This project successfully synthesizes a superhydrophobic sponge by modifying MOFs.The process mainly using click reaction make internal framework rearrange to enhance superhydrophobicity while preserving high porosity. The AlTz-68-C18 achieves an exceptional specific surface area and superior hydrophobic properties. It is then covalently bonded to the melamine sponge, demonstrating practical feasibility for oil-water separation in industrial and environmental applications.
Expected Benefit	The AlTz-68-C18@sponge synthesis process saves raw materials and energy while reducing maintenance costs compared to traditional waterproof coatings or surface treatments, exhibiting efficient oil-water separation and significantly improves oil adsorption efficiency at low cost and energy consumption. These discoveries not only advance materials science, but also provide practical solutions for future sustainable development and environmental protection

No. : **INTL 02**

Works : Application of a New High-Gain Power Converter in Next-Generation Renewable Energy Systems

School : NTNU (Taiwan); NTUST(Taiwan)

Department : Undergraduate Program of Vehicle and Energy Eng. NTNU; Dept of Electrical Eng. NTUST

Advisor : Asst. Prof. Hwa-Dong Liu **/** +886-2-7749 5953 **/** hdliu@ntnu.edu.tw
Prof. Chang-Hua Lin **/** +886-2-2730 3289 **/** link@mail.ntust.edu.tw

Leader : Mosaib Ul Munieeb **/** +886-9-7586 8244 **/** mosaibsufi199@gmail.com

Member : Tauseeque Ahmed Sahito Jyun-Wei Shih Wei-Yu Chen

ITEM	DESCRIPTION
Introduction of Team	Prof. Chang-Hua Lin guides the team from NTUST (Taiwan) and Assistant Prof. Hwa-Dong Liu from NTNU (Taiwan), both experts in power electronics. Mosaib Ul Munieeeb (Leader) and Tauseeque Ahmed Sahito are master's students specializing in power electronics at NTUST. Jyun-Wei Shih and Wei-Yu Chen, master's students from NTNU, are also part of the team. The Team is currently working on innovative DC-DC power converters.
Creation Motive (Problem-solving and technical value)	This project aims to improve solar energy systems to combat greenhouse gas emissions from fossil fuels. Our high-gain power converter addresses low-voltage output, enhancing solar applications.
Research Process	We developed a high-gain boost converter for Renewable Energy Systems Featuring a non-isolated design with voltage multiplier cells, it maximizes voltage gain and reduces switch stress. Our prototype operates at 30 V–60 V input, delivering 380 V–390 V output at 192 W with 96 % efficiency, reaching 99 % with MPPT.
Brief of Work (Creativity/Technical content and feasibility)	The converter's single-switch topology simplifies control and boosts efficiency. It amplifies voltage with minimal switch stress, ensuring reliability. This makes it ideal for integrating renewable energy into power grids.
Expected Benefit	The high-gain converter significantly boosts energy efficiency and reduces loss with advanced power management and MPPT technology, optimizing solar power output. It integrates seamlessly with grids, excelling in solar and DC systems. With a novel, cost-effective design using two inductors, six capacitors, and seven diodes, it costs about 700 TWD per unit and achieves over 96 % efficiency, surpassing traditional transformers. Its 200 W capacity makes it versatile for various Solar applications. For detailed information, scan the QR code provided.

No. : **INTL 03**

Works : Advanced Carbon Capture and Elimination Process Technology using Membrane Engineering (ACCEPT-ME)

School : National Taiwan University

Department : Department of Chemical Engineering

Advisor : Kang Dun Yen **/** 0932916418 **/** dunyen@ntu.edu.tw

Leader : Wu Po Chun/0966590680/aa0983690671@gmail.com

Member : Lee Sher Ling　Yu Yuan ChenChang　Shou Feng

ITEM	DESCRIPTION
Introduction of Team	The team is guided by Dr. Kang Dun Yen. Dr. Kang Dun Yen is an expert in CO_2 capture and MOFs. Wu Po Chun and Yu Yuan Chen are focusing their study on membrane separation and membrane adsorption, respectively. Lee Sher Ling is studying advanced materials. Chang Shou Feng is analyzing the cost for this process.
Creation Motive (Problem-solving and technical value)	The continuous increase in global carbon dioxide emissions, particularly with power plants contributing 47% of energy-related greenhouse gases, underscores the urgent need for innovative technology. Traditional carbon capture methods, such as chemical absorption, have high energy consumption and operational costs. To reduce the energy consumption and operational costs required for carbon capture, ACCEPT-ME focuses on developing membrane adsorption and separation materials.
Research Process	The ACCEPT-ME process first undergoes membrane adsorption, followed by membrane separation. To facilitate practical applications, we prepare the membrane as a hollow fiber module. This configuration allows for an extensive membrane surface area within a minimal volume, providing extremely high space utilization.
Brief of Work (Creativity/Technical content and feasibility)	ACCEPT-ME captures low concentrations of carbon dioxide and concentrates it to purity levels exceeding 99%, providing a more efficient, cost-effective, and scalable solution for global carbon neutrality. This technology not only complies with international regulatory requirements but also supports various industries in achieving their carbon reduction targets.
Expected Benefit	Compared to the traditional amine absorption process, ACCEPT-ME, which incorporates membrane adsorption and membrane separation, can undeniably cut the cost needed for carbon capture, which may encourage authorities to commit in the mission to mitigate climate change

No. : **INTL 04**

Works : Low-Cost Energy-Efficient Atmospheric-Pressure Plasma Jet Processed NiCo-Metalorganic Framework Electrocatalyst in Anion Exchange Membrane Water Electrolysis Module

School : National Taiwan University/National Taiwan University of Science and Technology

Department : Institute of Applied Mechanics/Graduate Institute of Photonics and Optoelectronics/Department of Chemical Engineering/Graduate School of Advanced Technology

Advisor : Dr. Jian-Zhang Chen Dr. I-Chun Cheng Dr. Meng-Jiy Wang

Leader : Zhi-Hui Pu

Member : Shuo-En Yu Chen-Chen Chueh Ci-Song Chen Bo-Yan Hong Hsing-Chen Wu Shang-Lin Hsieh Jui-Yu Tung

ITEM	DESCRIPTION
Introduction of Team	We are a joint research team from National Taiwan University and National Taiwan University of Science and Technology. The team is guided by Dr. Jian-Zhang Chen, Dr. I-Chun Cheng, and Dr. Meng-Jiy Wang, and is dedicated to research in the fields of hydrogen energy and plasma technology.
Creation Motive (Problem-solving and technical value)	As the demand for renewable energy continues to increase, its intermittency problem must be resolved. By storing hydrogen, peak shaving can be achieved to stabilize the grid. AEMWE combines the advantages of both AWE and PEMWE, it is currently in the research and development stage. The high potential of OER greatly limits the development of AEMWE.
Research Process	The research uses an energy-efficient, ultrafast APPJ process to rapidly oxidize the non-precious material electrocatalysts, thereby enhancing the activity and durability of the electrocatalysts.
Brief of Work (Creativity/Technical content and feasibility)	NiCo-MOF was grown on carbon paper using a solvothermal method and treated with an APPJ to enhance the OER activity and durability. APPJ is a low-cost, high-energy-efficiency, and easy operation method for ultrafast processing. It achieves this through two key features of APPJ: no need of vacuum system and the ability for rapid thermal annealing.
Expected Benefit	APPJ treatment improves the AEMWE performance and lowers the energy consumption. With 60 second APPJ treatment on NiCo MOF, the energy consumption reduces to 48.9 kWh/kg. The AEMWE degradation rate decreases from 718.3 to -118.3 μV/h. The results confirm that APPJ treatment offers a promising solution to improve the performance and durability of AEMWE.

No. : **INTL 05**

Works : Integrating a novel Costal Wave Energy Converter and Carbon Negative Cement for Net Zero

School : National Cheng Kung University,Leiden University& Delft University of Technology

Department : Program on Smart and Sustainable Manufacturing /Industrial Ecology Master's Program/Department of Civil Engineering

Advisor : Ou Ting-Chia / 0920829176 / outc@gs.ncku.edu.tw

Leader : Ju Zhi-Chin / 0920966370 / a0920966370@gmail.com

Member : Chen Shu-　ErChen Yu-Tung

ITEM	DESCRIPTION
Introduction of Team	We are a team comprised of individuals from Cheng Kung University, Leiden University&Delft University of Technology, bringing together expertise from diverse fields.
Creation Motive (Problem-solving and technical value)	The novel Costal Wave Energy Converter (CWEC) addresses five key issues: Taiwan's underdeveloped wave energy, low efficiency of traditional systems, high carbon emissions from conventional cement, green energy shortages and lack of autonomy, and high initial wave energy investment costs.
Research Process	To support Taiwan's net-zero goals, we developed the CWEC—a wave energy system with integrated flywheel storage—focusing on green energy innovation and transformation.
Brief of Work (Creativity/Technical content and feasibility)	Our project includes three components: The Coastal Wave Energy Converter (CWEC) improves Oscillating Water Column (OWC) technology, achieving 80% efficiency with carbon-negative cement and optimized design. A Flywheel Energy Storage System (FESS) stabilizes output and ensures grid compliance. Carbon-negative cement, which absorbs 12.8g of CO_2 per kg, cuts cement use by 40% and gravel by 70%, reducing the carbon footprint from 21.1 tCO_2eq to -4.52 tCO_2eq.
Expected Benefit	Deploying CWEC systems along Taiwan's 1,314 km coastline could harness 0.1% of its 10,000 MW wave energy potential, generating NTD 4.39 billion in green energy benefits. Replacing 2 million tons of wave-dissipating blocks with carbon-negative cement could cut 1.8 million tons of CO_2 emissions and sequester 25,600 tons, providing NTD 4.5 billion in carbon-negative benefits. CWECs could also enhance biodiversity, serve as artistic installations, and support net-zero goals and UN SDGs 7, 9, 13, and 14.

No. : **INTL 06**

Works : Green and Advanced Magnesium-based Hydrogen Storage Alloy

School : National Taiwan University

Department : Department of Materials Science & Engineering

Advisor : Dr. Tzong-Lin Shieh / 0927729646 / jayshieh@ntu.edu.tw

Dr. Hung-Wei Yen / 0918196735 / homeryen@ntu.edu.tw

Leader : Ting-Si Lin / 0911485612 / wisdom1020410@gmail.com

Member : Hao-Chun Hung Yu-Ching Hou Bo-Xiang Chen Yu-Hsiang Wang

ITEM	DESCRIPTION
Introduction of Team	The team consists of graduate students from the hydrogen energy group at the College of Engineering of NTU, and the research is guided by Dr. Tzong-Lin Jay Shieh and Dr. Hung-Wei Homer Yen, with expertise in solid-state hydrogen storage and metallurgy.
Creation Motive (Problem-solving and technical value)	Conventional hydrogen storage methods face challenges: high-pressure gaseous storage has safety concerns, and liquefied storage is costly due to cryogenic conditions. Solid-state hydrogen storage alloys (HSAs) are safe but have low capacities and use expensive or rare-earth elements. Among them, Mg offers a higher capacity but operates at high temperatures with complex production routes. Our advanced Mg-based hydrogen storage alloy addresses these issues by providing a high-capacity, easy-processed, low-cost solution.
Research Process	Refining ZK60 Mg alloy chips into HSA powders using high-energy ball milling takes at least 24 h, and the H_2 storage-release kinetics require precious metal catalysts. To overcome these challenges, we use an atomized powder process and develop non-Pd/Pt catalysts. These innovations make the production of Mg-based HSA more efficient and cost-effective, ready for industrial applications.
Brief of Work (Creativity/Technical content and feasibility)	We develop an Mg-based HSA with high storage capability (5.5-6.5 wt. %) and long durability (> 200 cycles). The operation temperature is controlled at 300°C at 3 MPa H_2, reaching an energy density of > 80 MJ/kg H_2. We achieve sustainability and industrial practicality by mixing commercial and recycled Mg alloys via a simplified large-scale process and adopting non-precious metal catalysts.
Expected Benefit	The major benefit of our technology is providing a safe, efficient, and robust hydrogen storage solution for various applications, such as isolated or military-wise storage, long-distance transportation, and emergency power supply. Our Mg-based HSA can contribute significantly to the global net-zero emissions goal by 2050.

No. : **INTL 07**

Works : EcoSphere: A Model for Sustainable and Effective Learning Environment

School : Sunway University

Department : School of Engineering and Technology (SET) / Arts (SOA)

Advisor : Prof Ir Denny Ng Kok Sum Prof Angela Lee
Dr Nicole Fu Wincen Foong

Leader : Lewis Tee Jen Looi

Member : Andrea Tan Chiao Pin Deaberniswarar Sharmaa Jason Kow Jonathan Jared Ignacio May Yeap Mun Yi Willion Yap Wei Yen

ITEM	DESCRIPTION
Introduction of Team	The student team is formed by postgraduate students, Lewis (SET), Jonathan (SET), and Jason (SOA); undergraduate students, Andrea, Deaberniswarar (SET), May, and Willion (SOA). They are advised by Prof Denny and Prof Angela from SET; Dr Nicole and Wincen from SOA, Sunway University.
Creation Motive (Problem-solving and technical value)	This project, EcoSphere, aims to decarbonize an education building based on carbon emission during building construction and operation phase. The carbon emission is based on Scope 1 (onsite emission) and Scope 2 (offsite emission due to raw materials and energy usage). In this project, instead of using complicated architectural design that may be costly to design and build, EcoSphere applied a stack of over 10 NetZero Technologies to a traditional building design to achieve carbon neutrality, while maintaining cost within 20% of a typical building of the same size.
Research Process	Construction of the building started in Q3 2024, targeting completion by Q1 2026. The 10+ NetZero work packages are managed through three categories: TerraGuard (solid & sustainable materials), Aquazen (water & efficient cooling), AirScape (air & energy management).
Brief of Work (Creativity/Technical content and feasibility)	TerraGuard, using green concrete and materials, waste management, upcycling, and carbon capture paint, reduced the embodied carbon from 907 t CO_{2e} to 429 t CO_{2e}. AquaZen, using heat insulative paint, district cooling, and rainwater harvesting system; AirScape using air conditioning energy recovery system, building energy management system, and solar PV microgrid operates at -30 t CO_{2e} per annum.
Expected Benefit	Through the negative offset produced during operation and taking into consideration the replacement of solar PV every 10 years, the EcoSphere building will achieve NetZero carbon emission in 19 years. This building with a GFA approx. 5000m^2, houses 28 classrooms, 2 studios, and 5 labs. It expands university student capacity by 2000 and will be the 1st NetZero building on campus. By using Technology to achieve NetZero, EcoSphere is a pioneering model and a scalable solution for other buildings on campus.

No. : **INTL 08**

Works : Novel process design and validation for decreasing CO_2 emission from cement production decarbonization

School : National Cheng Kung University

Department : Department of Chemical Engineering (CHE) / Department of Civil Engineering (CE)

Advisor : Dr. Wei Wu (CHE) Dr. Chi-Ming Lai (CE)

Leader : Chi-Yun Wu

Member : Chen-Yu Chang Debayan Mazumdar Qing-Hao Zeng

ITEM	DESCRIPTION
Introduction of Team	This is a cross-nationality and cross-professional team. One of the advisors, Dr. Wei Wu, is a Professor of Chemical Engineering (CHE), specializing in process design and carbon dioxide (CO_2) capture. Dr. Chi-Ming Lai, Professor of Civil Engineering (CE), specializes in energy-saving buildings. Team member Chi-Yun Wu is a CE master student and he focuses on cement kiln dust (CKD) process and energy optimization. Debayan Mazumdar, Qing-Hao Zeng, and Chen-Yu Chang are master's students of CHE. They focus on process design, computational fluid dynamics (CFD), and decarbonization.
Creation Motive (Problem-solving and technical value)	Cement production is one of the major sources of global greenhouse gas emissions, accounting for approximately 7% of global CO_2 emissions, mainly from the decarbonization process during calcination. In this project, calcium looping process (CLP) was employed to improve overall technical and environmental efficiencies. How the novel design integrates with existing process was also considered. The technical values include: (1) Significant reduction of CO_2 emissions. (2) Utilization of cement kiln dust (CKD) waste. (3) Almost net-zero emissions of cement production. (4) Enhancement of product quality and yield.
Research Process	(1) Decoupling the traditional production processes of cement plants and looking for possibilities to improve technical and environmental efficiency. (2) Exploring the Capturing CO_2 via CLP was explored. (3) Design-thinking the possibility of reusing and storing captured CO_2. (4) Using the software Aspen Plus® to conduct the validation works.
Brief of Work (Creativity/Technical content and feasibility)	(1) Significant reduction of CO_2 emissions: A new process integration of CLP and Tri-ethylene Glycol (TEG) dehydration process for capturing and purifying CO_2 is proposed, achieving at least 4N level (99.99% purity) of CO_2 is achieved. (2) Utilization of cement kiln dust (CKD) waste: A new process is developed to produce carbonated CKD products as cement additives by consuming CO_2. The reuse of CKD not only reduces raw materials and environmental pollutions but also increases the cement yield. (3) Almost net-zero emissions of cement production: 12.33% of CO_2 is stored in the cement and 85.56% of CO_2 is 4N CO_2 product. (4) Enhancement of product quality and yield: Carbonated CKD products is validated to improve the strength and durability of cement. This cement additives enhance throughput and economics.
Expected Benefit	(1) The proposed novel process enables the integration and application of the mineral carbonation of CKD (MCCKD), CLP, and TEG dehydration processes into the existing cement industry. (2) The novel cement production is almost net-zero emissions, and the cement yield is increased by 17.65%. (3) Of particular emphasis in this project was that compared to conventional cement production, implementation of the proposed MCCKD process can possibly reduce direct CO_2 emissions by 9.2-13.4%.

No. : **INTL 09**

Works : Next-Generation Redox-Mediated Bipolar Membrane Electrodialysis: Simultaneous Seawater Desalination and Carbon Capture

School : National Taiwan University

Department : Graduate Institute of Environmental Engineering

Advisor : Chia-Hung Hou **/** 0233664400 **/** chiahunghou@ntu.edu.tw

Leader : Min-Chen Wu **/** 0936288039 **/** f08541111@ntu.edu.tw

Member : Jui-Yao Chang　Yu-Hui Kao　Po-Yen Wang　I-Wei Chen

ITEM	DESCRIPTION
Introduction of Team	Our team, led by Prof. Chia-Hung Hou, focuses on electrochemistry and material development to create innovative electrochemical water treatment technologies, addressing current water treatment challenges through cutting-edge research and innovation.
Creation Motive (Problem-solving and technical value)	Accelerated industrial growth has led to increased carbon dioxide emissions and water shortages. Traditional seawater desalination technologies consume significant energy, making it crucial to develop alternative methods.
Research Process	The five-channel redox-mediated BMED system leverages BPM's alkaline production in conjunction with redox reactions, electron transfer, and ion migration mechanisms to efficiently desalinate seawater and recover valuable calcium carbonate, supporting the pursuit of sustainable development with negative carbon emissions.
Brief of Work (Creativity/Technical content and feasibility)	The BMED system, consisting of electrode plates, a BPM, two CEMs, and an AEM, creates five chambers and uses recirculated redox-mediated materials to reduce voltage losses. Continuous redox reactions ensure high ion separation efficiency with low energy use. The BPM generates an alkaline environment, promoting carbonate formation and calcium carbonate precipitation for carbon capture. To maintain charge balance, ions migrate through ion exchange membranes to remove ions from seawater, producing a desalinated solution.
Expected Benefit	This innovative system operated at 1 V for 60 minutes, raising the pH in the alkaline chamber from 7.9 to 10.23, which created optimal conditions for calcium carbonate precipitation. Simultaneously, the conductivity of synthetic seawater in the diluted chamber decreased from 49.2 mS/cm to 46.9 mS/cm, indicating its potential for generating freshwater. The redox-BMED system consumes 0.95 kWh/m^3, significantly lower than the ED system's 2.2 kWh/m^3, marking a critical step toward achieving net-zero carbon emissions.

No. : **INTL 10**

Works : A novel up-scaling process of a photoelectrochemical (PEC) system with H_2 generation for real saline sewage treatment: taking pioneering steps towards net zero wastewater treatment technology

School : The Hong Kong University of Science and Technology

Department : Department of Civil and Environmental Engineering

Advisor : Chair Prof. Irene M. C. Lo / +852 6012 0266 / cemclo@ust.hk
Dr Zexiao Zheng / +852 6709 7367 / timmy.zheng@ust.hk

Leader : Taoran Dong / +852 9587 7288 / max.dong@connect.ust.hk

Member : Hoi Kit Jutin Man   Cheuk Wai Lung

ITEM	DESCRIPTION
Introduction of Team	The team is led by Chair Prof. Irene M. C. Lo and Dr Zexiao Zheng. Prof Lo has dedicated her effort in wastewater treatment for over 32 years and is also a licensed carbon auditor in the US and HK, while Dr Zheng has been working on photocatalytic material development. Taoran Dong, Hoi Kit Justin Man and Cheuk Wai Lung are PhD students focusing their research on the low carbon PEC treatment of saline sewage along with H_2 generation.
Creation Motive (Problem-solving and technical value)	Conventional wastewater treatment plants (WWTPs) have been limited by their intensive carbon emissions and energy consumption, as well as the generation of carcinogenic disinfection byproducts (DBPs). By the the possibility of developing a chloride-activating PEC system for reactive chlorine species (RCS) generation with highly saline sewage in Hong Kong, we are inspired to develop a multifunctional PEC system for sewage treatment and H_2 generation, which can solve the limitations of conventional WWTPs by utilizing H_2 as green energy and reducing DBPs formation, stepping towards net zero sewage treatment.
Research Process	Laboratory studies by the batch reactor were first conducted for proof-of-concept and mechanistic investigation. Further up-scaling design of PEC cell was then made, featuring enhancement in reactor layout and design. Continuous flow PEC studies were conducted by the large-size PEC reactor to evaluate its practicality and feasibility of reaching net zero wastewater treatment.

Brief of Work (Creativity/Technical content and feasibility	Batch study revealed the PEC system's ability to perform pollutants removal and bacteria inactivation, along with H_2 generation. It could be attributed to the RCS for directly degrading chemical oxygen demand and ammonia-nitrogen, as well as *E. coli* inactivation; along with the photogenerated electrons for H_2 generation. Based on the results above, several creavtive design features of PEC cell have been incorporated during the up-scaling process, including top-fixed photoanodes with larger surface area to enhance the light absorption ability and the interaction between sewage and photoanodes, bottom-up flow to prevent dead zones and promote mixing, as well as using graphite as electrode holders to minimize reactor cost and avoid corrosion. The feasibility and technical value of the PEC system has been proved by the better quality of the treated effluent by the invented large-size reactor than that from the batch reactor, which meet the discharge standards of WWTPs in Hong Kong, with a significantly shorter retention time (2 hrs) needed than that from the activated sludge process (9 hrs). Moreover, the 1.91-fold increment in H_2 generation (18.13 mol/m^3) and the 95.5% reduction in total carbon emissions highlight the feasibility of reaching net zero wastewater treatment by the developed PEC technology.
Expected Benefit	By encouraging coastal cities to use seawter flushing for saving freshwater resources, the industrialization of the chloride-activating PEC treatment can be promoted, contributing to the effort of reaching net zero wastewater treatment. Through the substitution of secondary treatment in a real WWTP in Hong Kong by the PEC technology, 304.750 tonnes of annual carbon emission can be potentially reduced, while USD 42.6-56.4 million of economic benefits can be brought by carbon reduction. The H_2 generated by PEC system could also potentially bring 470 million kWh of annual green energy generation, equivalent to the consumption of 98,000 households. The substantial socioeconomic benefits brought by the application of the PEC technology have therefore been proved.

No. : **INTL 11**

Works : E-Sense Power

School : Aalborg University

Department : AAU Energy

Advisor : Huai Wang/(+45) 99403816E/hwa@energy.aau.dk

Leader : Xing Wei/(+45) 81902462/xwe@energy.aau.dk

Member : Yichi Zhang Yongjie Liu Bo Yao Jiahong Liu

ITEM	DESCRIPTION
Introduction of Team	The team is from Aalborg University, Denmark, supervised by Prof. Huai Wang, a globally renowned expert in power electronics reliability, and consists of 5 PhD students. Over the past decade, the team devoted to the reliability design and condition monitoring of power electronic systems.
Creation Motive (Problem-solving and technical value)	Subject to long-term operating and environmental stresses, unscheduled failures in renewable energy systems frequently occur. This compromises their sustainability and efficiency, while increasing downtime losses, maintenance costs, and environmental pollution. An innovative condition monitoring solution is urgently needed to enhance the reliability of renewable energy systems, promoting the global net-zero targets.
Research Process	The research process for this project is divided into four key phases: 1) Identify reliability-critical parts in renewable energy systems. 2) Develop hardware and software for data acquisition and processing. 3) Deploy prototypes to the field for diagnostic and prognostic validation. 4) Develop commercial products meeting industry standards.
Brief of Work (Creativity/Technical content and feasibility)	E-Sense Power is the world's first wearable condition and health monitoring solution for renewable energy systems. It acts as a Dedicated Doctor with diagnostic and prognostic capabilities, providing actionable insights for operational optimization and proactive maintenance. E-Sense Power consists of 3 parts: 1) E-Sense Power Sensor is the hardware-based data acquisition instrument; 2) IoT Platform acts as a communications hub and provides user-friendly web interfaces; 3) Intelligent "Brain" is an AI-based core engine for health assessment and failure prediction.
Expected Benefit	E-Sense Power will empower renewable energy systems with diagnostic and prognostic capabilities to avoid accidents, enhancing their availability and efficiency. With zero-failure periods, downtime losses, maintenance costs, and electronic pollution of renewable energy will be minimized, improving the economic and ecological benefits. E-Sense Power will set new reliability standards for renewable energy and contribute to a more sustainable, economical, enviro-friendly, and intelligent energy future. The first-generation product of E-Sense Power has been successfully developed and granted a U.S. patent. The expected markets include train traction, metro, wind power, PV, e-mobility, and industry drives. Market entry is strategically planned in three phases: short term with $45 million, medium term with $50+ million, and long term with $100+ million.

No. : **INTL 12**

Works : A rechargeable zinc-air battery enabled by a solid hydrogel electrolyte in both atmospheric and low-temperature conditions

School : National Yang Ming Chiao Tung University

Department : Biomedical Engineering

Advisor : Liu Ta-Chung / 0963732731 / tcliu@nycu.edu.tw

Leader : Hsu Chen- Xuan / 0903664553 / hydra20000819@gmail.com

Member : Yang Jung-Hao He Shao-Chi Weng Yung- Cheng

ITEM	DESCRIPTION
Introduction of Team	We utilized 3D printing to develop a non-alkaline rechargeable solid-state zinc-air battery with feeding atmospheric air. To demonstrate the practical application, we integrated our air battery with a laboratory-level electrolytic hydrogen production system and our air battery can charge electronic watches with only a very low-flow (5 cc/min) input from the output of ambient hydrogen system. To display its adaptability in low temperatures, we tested our air battery in a -40 ℃ chamber controlled by mixed liquid nitrogen/ice and showed only ~30% decrease in performance compared to room temperature, displaying its great potential in electric vehicles and electric grids in high latitudes areas.

No. : **INTL 13**

Works : The Decarbonizer: A Comprehensive Solution for Waste Reduction and Hydrogen Production

School : National Cheng Kung University and National Sun Yat Sen University

Department : Department of Aeronautics and Astronautics/Mechanical and Electro-Mechanical Engineering/International Degree Program on Energy Engineering

Advisor : WEI-CHENG WANG / 06-2757575 ext. 63628 / wilsonwang@mail.ncku.edu.tw

Leader : Rusdan Aditya Aji Nugroho / 6-2757575 Ext. 63642 / rusdanaditya@gmail.com

Member : 鄭宇　林明叡　Muhammad Azmi

ITEM	DESCRIPTION
Introduction of Team	The team is guided by Professor Wei-Cheng Wang, his dedicated research on the Net Zero Emission such as Hydrogen Production, Sustainable Aviation Fuel production, Clean Combustion Technology and Aviation industry toward Fly Net Zero. Rusdan Aditya Aji Nugroho is a PhD student focusing his study on carbonization through thermal treatment and hydrogen production. Muhammad Azmi, 林明叡 and 鄭宇 is currently study master degree with a focus research on hydrogen production in plasma-assisted gasification system.
Creation Motive (Problem-solving and technical value)	Transforming agricultural waste, often seen as a problem, into clean energy is at the fundamental of the Decarbonizer project. By using plasma-assisted gasification, this system converts 55% of agricultural waste, which has no commercial value, into valuable hydrogen. This not only provides a sustainable energy solution but also helps reduce environmental degradation. Hydrogen, the fuel of the future, offers nearly limitless clean energy with only water vapor as a byproduct.
Research Process	The overall key stages of the search process in the Decarbonizer project are as follows: 1. Feedstock Preparation 2. Plasma-Assisted Gasification 3. Hydrogen Purification System 4. Fuel Cell Integration 5. System Optimization
Brief of Work (Creativity/Technical content and feasibility)	The technology proposed here is based on waste-to-energy principles aimed at achieving Net-Zero emissions and promoting hydrogen energy. The Decarbonizer is composed of 3 modules: 1. Thermal Decomposition module, which applies aero swirler technology assisted by a plasma system to convert waste into syngas with high hydrogen concentration. 2. Hydrogen Purification module, applying aerodynamics concepts to produce and purify hydrogen. 3. Power Transmission module, where a hydrogen fuel cell generates approximately 4 kW of electricity. Around 10% of the feedstock is converted into bottom ash, which can serve as a resource for absorbents or negative electrode materials for lithium batteries.
Expected Benefit	The Decarbonizer operates at a capacity of 10 kg/hr, achieving a 90% reduction in agricultural residue. The process cost for Decarbonizer waste is 21 NTD/kg. Its carbon emissions are 5.17 kg CO_2 eq/hr, with a decarbonization efficiency of 88%. This custom-made, automatic, continuous-processing equipment has dimensions (L*W*H) of 1550*2600*1600 mm, requiring approximately 6.6 m^2 of floor space and weighing 480 kg. In additions, The Decarbonizer offers on-site waste treatment, eliminating issues related to transportation and regulation.

No. : **INTL 14**

Works : Seaweed Afforestation: Unlocking the Ocean's Potential for Carbon Sequestration

School : National Taiwan University

Department : Department of Geosciences

Advisor : Haojia Abby Ren　Tung-Yuan Ho　Jui-Sheng Chang　Brandon Stephens / 0928172624 / abbyren@ntu.edu.tw

Leader : Carel Tan / 0905293414 / carel.tan236@gmail.com

Member : Ren-Yi Cai-Li　Yu-Chen Yen

ITEM	DESCRIPTION
Introduction of Team	The team is composed of Carel Tan (Dept. of Geosciences, NTU) studying the nutrient cycling processes in seaweed, Ren-Yi Cai-Li (Dept. of Geosciences, NTU) investigating upper ocean nutrient cycling and biological processes in the ocean, and Yu-Chen Yen (Institute of Oceanography, NTU) working on production and degradation processes of dissolved organic carbon in the ocean. Our team is supervised by Dr. Haojia Ren (Dept. of Geosciences, NTU) specializing on large scale biogeochemical processes in the ocean and long-term carbon storage in the ocean, Dr. Tung-Yuan Ho (Research Center for Environmental Changes, Academia Sinica) working on how nutrient, including major nutrients and trace elements, regulate biological productivity in the ocean, Dr. Jui-Sheng Chang (Center of Excellence for the Oceans, National Ocean University) expert on seaweed phylogeny and seaweed cultivation, and Dr. Brandon Stephens (Institute of Oceanography, NTU) studying the cycling of dissolved organic carbon in the ocean.
Creation Motive (Problem-solving and technical value)	Seaweed aquaculture is the fastest-growing sector in global food production and offers a range of opportunities for mitigating and adapting to climate change. Taiwan is adjacent to deep-sea environments and is home to over 600 species of tropical and subtropical native seaweeds, providing a natural advantage for deep-sea carbon sequestration through seaweed aquaculture. Our project aims to construct the first typhoon-resistant offshore seaweed farm along the continental slopes leading to deep ocean carbon storage. We will pioneer the development of quantitative analysis methods for offshore seaweed aquaculture carbon sequestration.

Research Process	Since October 2023, we've set up a 300-square-meter seaweed farm off the coast of Taitung. The seaweed farm has endured the winter monsoons and super typhoon Gaemi. Currently, the farm is supporting the growth of 120kg of various seaweed species. We apply multiple scientific methods to monitor the seaweed growth, sinking, and estimate its carbon fluxes.
Brief of Work (Creativity/Technical content and feasibility)	**We are the first team to successfully construct offshore seaweed farm in Taiwan, and among the very few cases around the globe where seaweed farms are constructed along the continental slopes leading to deep ocean carbon storage.** We monitor the growth rates of the seaweed monthly and quantify carbon flux to the deep ocean. Our results show that seaweed sinks in large pieces, settling quickly into the deep ocean. Using underwater acoustics, we estimate that seaweed particles sink several meters per hour, much faster than other marine phytoplankton. Based on our growth and sinking rate measurements, we estimate that 170 to 1700 square meters of ocean are needed to remove 1 tonne of carbon dioxide annually. This uncertainty largely arises from environmental constraints including light, nutrients and other factors that may affect seaweed growth. Laboratory experiments are underway to understand these environmental constraints.
Expected Benefit	Seaweed farming in these offshore environments offers significant potential for achieving zero carbon goals. **If 10% of Taiwan's territorial waters were used for seaweed cultivation, it could sequester 2.6 million tonnes of carbon dioxide annually, equivalent to 1% of Taiwan's total emissions.** Besides removing carbon dioxide from the atmosphere and sequestering it in the deep ocean, our offshore seaweed farm has significantly increased fish populations and ecosystem diversity by offering habitats and food sources. This technique is environmentally friendly and can be integrated with fisheries, marine aquaculture, and other marine businesses.

No. : **INTL 15**

Works : Ultrahigh Efficiency Bidirectional DC-DC Converter for Energy Storage and Super Charger Applications

School : Virginia Polytechnic Institute and State University

Department : Electrical and Computer Engineering

Advisor : Jih-Sheng Lai / +1-5408181023 / +886-928523689/laijs@vt.edu

Leader : Bryan Gutirrez / +1-5402675906 / Bryangs@vt.edu

Member : Hsin-Che Hsieh Ching-Yao Liu

ITEM	DESCRIPTION
Introduction of Team	Two universities form the team with Virginia Tech Future Energy Electronics Center (VT-FEEC) leading the effort of hardware development while National Yang Ming Chiao Tung University students assisting device and prototype testing. In 2016 Google Little Box Challenge among 2000+ international teams including General Electric and Schneider Electric, VT-FEEC was the Top-3 winner and the only winner from academia and US-Taiwan combination.
Creation Motive (Problem-solving and technical value)	Currently the battery charger efficiency of commercial product is <95%, which needs to be significantly improved to help expedite the CO_2 reduction. Recently with wide bandgap devices available and the battery voltage level moving up to 1 kV and above, it is possible to design a battery charging system with round-trip efficiency higher than 99.5.
Research Process	There are two major loss components in a power conversion system: switching device and magnetic component. Our approach is to eliminate the switching loss by a smart computation to eliminate the switching loss under multiple device or converter paralleled condition and to move up the switching frequency to reduce the magnetic component size and loss. The switching method is called "synchronous conduction mode" (SCM) or transition mode (TM), which produces a triangular current that contains a negative portion to produce sufficient energy to discharge the semiconductor junction capacitance during switching to eliminate the switching loss.

Brief of Work (Creativity/Technical content and feasibility)	The proposed system consists of (1) energy sources including renewable energy source and (2) a common DC bus with kilo-volt level, and (3) a bidirectional DC-DC converter. The key development here is the “ultrahigh efficiency” DC-DC converter, which is now widely used in energy storage and EV super chargers. The input is 1 kV, and the output is a battery with 800-V nominal. The project goal is to increase the efficiency while reducing the size and cost. The resulting peak efficiency occurs under 1kV/15A full-load condition, in which the measured efficiency is 99.821%. From 600V to 1kV, the converter runs in constant power mode with output of 15 kW. Below 600V, the converter runs in constant current mode with a current of 25A. from 250V to 1kV, the efficiency maintains 99% and higher. The first aspect of energy saving impact area is in energy storage applications. Using US Energy Information Agency (EIA) data, the annual green energy generation is 9000TWh in 2022. Assuming 10% of this energy needs to be stored, it will amount to 900 TWh. As an average, each 500-MW coal-fire power plant produces 3-TWh electricity per year, the use of our ultrahigh efficiency bidirectional DC-DC converter will help save at least 160 coal-fire plants. The second aspect of energy saving area is in EV super charging applications. According to International Energy Agency (IEA), the number of fast charger stations reached 2.7 million at the end of 2022 with 5% growth annually. Assume each charging station is rated 100 kW and operate 10 hours a day in average. The global energy usage will be 2.7 TWh per day, and the annual energy saving will be 49 TWh. With the use of our ultrahigh efficiency DC-DC converter, the amount of coal-fire power plant elimination will be 16. A total of 176 coal-fire plants will be eliminated with our 99.8% bidirectional power conversion efficiency and loss reduction.

No. : **INTL 16**

Work : Eco Algae

School : University of Moratuwa

Department : Chemical and Process Engineering

Advisor : Dr. Tharushi Keerthisinghe / +94772847667 / tharushik@uom.lk

Leader : Isumi De Silva / +94704880101 / isumiyavindi@gmail.com

Member : Gavin Senaratne Januth Liyanage Janitha Dissanayake

ITEM	DESCRIPTION
Introduction of Team	The 4 members are chemical and process engineering undergraduates. The advisor, Dr. Tharushi Keerthisinghe, is an expert in Environmental Engineering, Environmental Chemistry, and Biochemical Engineering
Creation Motive (Problem-solving and technical value)	Agricultural runoff is a major surface water contaminant that causes ecosystem loss and eutrophication. The high cost of conventional tertiary wastewater treatment encourages farmers to dump untreated wastewater into fresh water bodies. This project designs an microalgae-based process to purify wastewater at a lower cost than existing methods while also capturing carbon and producing a feedstock to manufacture biofuels.
Research Process	Optimal algal species (*Chlorella* and *Scenedesmus* sp.) were selected through an extensive literature review for their high lipid content and carbon capture efficiency. The drawbacks of existing reactor designs were identified and novel designs for direct CO_2 injection and greenhouse covers were developed to address those issues.
Brief of Work (Creativity/Technical content and feasibility)	This project designs a model of a small-scale open pond algal bioreactor that can be deployed on-site to treat agricultural runoff. Its sole energy requirement is a low-rpm paddlewheel and the microalgae species are readily available in nature. Since the the main contaminants in agricultural runoff are also vital nutrients for microalgae, the additional costs of maintaining the algae growth media are minimal. In addition to being cheaper, this process is also carbon-negative. Using the spent microalgae to create products like biofuel can further offset operating costs.
Expected Benefit	This study aims to encourage wastewater treatment in agriculture by **reducing costs by over 85% relative to reverse osmosis**. Chlorella species of microalgae have been observed to **reduce nitrate and phosphate levels by 87% and 75%, respectively**, while also removing heavy metals and organic ions. The treated water may be reused for irrigation, assisting in water conservation efforts. Wastewater treatment using microalgae is a net carbon-negative process due to direct air carbon capture during photosynthesis. **Microalgae produces up to 280 tons of dry biomass per hectare, absorbing roughly 513 tons of CO2.**

No. : **INTL 17**

Works : Sao Paulo Net Zero Design and Net Zero Emiss Public Library

School : University of Indonesia

Department : Mechanical Engineering, Architecture

Advisor : Ardiyansyah Yatim, Ph.D, Dr.-Ing. Ir. Ova Candra Dewi S.T., M.Sc. GP., IPU/+628118116620/+6285810510540 / ardiyansyah@ui.ac.id / ova.candewi@ui.ac.id

Leader : eonardo Dillon / +6285853345988 / leonardodillon02@gmail.com

Member : Alexander Ganesh Aji Dewanto Heidy Sekardini Amar Falah Riyanto Farras Hafizh Al Farisi Vynna Alviolina Indriyana

ITEM	DESCRIPTION
Introduction of Team	The team, guided by experts Ardiyansyah Yatim, Ph.D., and Dr.-Ing. Ir. Ova Candra Dewi S.T., M.Sc. GP., IPU, focuses on green building and energy research. Members include architecture students Leonardo Dillon (Leader), Alexander Ganesh Aji Dewanto, and Heidy Sekardini, along with mechanical engineering students Amar Falah Riyanto, Farras Hafizh Al Farisi, and Vynna Alviolina Indriyana.
Creation Motive (Problem-solving and technical value)	São Paulo, the largest state in Brazil, has reached a 99% literacy rate (worldatlas.com). A public library, with a net-zero energy and emission concept was proposed to support it. The challenge lies in providing sufficient lighting for reading areas while conserving electricity and avoiding excessive heat from vertical fenestrations. Public buildings in tropical regions consume significant energy for cooling and lighting, emitting 200-300 kg of CO2/m2 annually (unep.org). Therefore, a holistic approach is needed to actually build this public library.
Research Process	To tackle the main issues of sufficient lighting, energy conservation, and excessive heat, design strategies use passive methods like orientation optimization, sunshade calculations, lighting analysis, and building envelope design, as well as active systems such as renewable energy and HVAC technology. The research employs parametric tools like Python, Grasshopper, Revit, Design Builder, PVsyst, and Autodesk Green Building for simulations, including life cycle assessment and cost analysis, to evaluate environmental and economic impacts. The goal is to achieve Net Zero Energy and Carbon status.

Brief of Work (Creativity/Technical content and feasibility)	1. Reduce Energy Demand by 73.65% Optimizing sunshade dimensions for the northwest to northeast direction reduces building energy use by 18.61% by minimizing artificial lighting, maintaining daylight at 200-500 lux in public rooms, and controlling heat gain by blocking summer sun and allowing winter sun. A central pond enhances evaporative cooling and natural ventilation, assisted by a criss-cross tapered brick facade at a 25.1°-26.3° angle, achieving comfortable wind velocities of 0.32 - 0.75 m/s. This reduces HVAC coverage by 651.2 m², lowering energy demand by 12.53%. ABNT NBR 15220-3 200 recommends light reflective or insulated colors; limestone's high albedo prevents excess heat absorption. Low-carbon thermal mass facades with native vegetation cover 3,437 m² of greenscape, absorbing 2,749 kg CO_2 and producing 2,750 kg O_2 annually, reducing energy by 21.26% through heat transfer control. A Ground Source Heat Pump (GSHP) using natural refrigerants ammonia and water, with 0 GWP, lowers compressor energy by 23.25% due to stable temperatures. 2. Renewable Energy: 28.61% Energy Generation Using renewable energy through parametric simulated solar PV systems. These systems provide an additional 28.61%, which results in a surplus by 4.26% in summer and overall net-zero energy. 3. Significantly Low Carbon Material By using locally sourced materials, our building achieved an embodied carbon benchmark of 142 kg CO_2e/m^2, granting it a Grade A rating in the Carbon Heroes benchmark for global educational buildings as of Q3 2023 through Life Cycle Analysis.
Expected Benefit	Optimizing building orientation and adding façade sun shades reduce lighting energy use by 18.61%. A light-colored limestone brick façade and indoor pond aid evaporative cooling and dehumidification, cutting HVAC energy demand by 12.53%. Thermal mass, solid façades, and native vegetation greenscaping enhance heat transfer efficiency, reducing energy consumption by 21.26%. A Ground Source Heat Pump (GSHP) lowers energy use by 23.25%, and photovoltaic installation leads to a 4.26% energy surplus in summer, achieving net-zero annual energy consumption.

No.	: **INTL 18**
Works	: Bromeliad Library: Achieving Net Zero Operation in Sao Paulo through Energy -Efficient Library with Clay Facades, Fog Catchers, and Sustainable Mechanical Systems
School	: Universitas Indonesia
Department	: Mechanical Engineering and Architecture
Advisor	: Dr. Miktha Farid Alkadri **/** +31647252439 **/** miktha@ui.ac.id
Leader	: Bimantyo Ganggas F.I. **/** +62 815-1988-0540 **/** bganggas05@gmail.com
Member	: Alfian Febrianto Alya Widha Aurellia Bimantyo Ganggas Fadhil I Miguel Bintang S Muflikh Kas Y Risma Fitriyanti

ITEM	DESCRIPTION
Introduction of Team	The team is guided by Ardiyansyah, S.T., M.Eng., Ph.D., and Dr. Miktha Farid Alkadri. Ardiyansyah is an expert in building engineering and air conditioning. Dr. Miktha Farid Alkadri is an expert in computational design, digital fabrication, and building performance simulation. Alya Widha Aurellia, Bimantyo Ganggas F.I., and Risma Fitriyanti are undergraduate students majoring in Architecture. Alfian Febrianto, Miguel Bintang Samuel, and Muflikh Kas are undergraduate students majoring in Mechanical Engineering.
Creation Motive (Problem-solving and technical value)	The BROMELIAD LIBRARY in São Paulo aims to create a net-zero green building to address the significant CO2 emissions from traditional buildings. It integrates passive strategies like maximizing natural light, reducing solar heat, and innovative facades for humidity control. Key features include the Fog Catcher for water reuse, Clay Facade for thermal insulation and daylight, and Bromeliad's Green Wall for reducing humidity and CO2 absorption. Active strategies focus on air quality, water management, and lighting, with advanced VRF systems, DOAS with demand control ventilation, LED systems with sensors, and efficient water management through rainwater harvesting and greywater recycling. Solar energy from photovoltaic panels ensures the building achieves net-zero energy. Together, these passive and active strategies help the building conserve energy and water, supporting net-zero energy and green building principles.
Research Process	In the research project's early stages, both passive and active building design strategies were examined, highlighting the often-overlooked passive strategies that can reduce energy consumption and environmental impact. The Bromeliad Library was chosen as a green building case study. Climate analysis of São Paulo's hot, humid climate with high rainfall and abundant solar energy informed the design. Passive strategies included a sustainable facade and a "fog catcher" for reducing humidity and collecting water, essential for preserving books. Experiments optimized the fog catcher's mesh size for water capture efficiency. A clay facade was selected for its cooling properties and ability

	to maintain surface temperature, while a Bromeliad Green Wall was added to increase green areas and reduce CO_2 emissions. After optimizing passive systems, the focus shifted to active systems, proposing advanced HVAC technology with VRF for thermal comfort and humidity control, DOAS with DCV for air quality, rainwater harvesting, greywater recycling, and occupancy-sensing LED systems for adaptive lighting.
Brief of Work (Creativity/Technical content and feasibility)	In the early stages, the building was adapted to a net-zero program using Grasshopper and Dialux simulations to optimize the facade design and fog catcher shape. The project identified the best facade configuration for capturing dew, filtering humidity, and blocking solar radiation. Key innovations included a fog catcher facade with a biomimetic shape that can enhance fog capture by up to 20%, converting humid air into dry air and collecting grey water, thus reducing electrical demand. Additionally, a clay facade using locally sourced materials was implemented to reduce solar radiation and maintain low temperatures, and a Bromeliads Green Facade with native plants was used to reduce humidity and require low maintenance. Active systems proposed included advanced HVAC with VRF for comfort and humidity control, DOAS with DCV for air quality, and occupancy-sensing LED systems for adaptive lighting. This integrated approach combines passive and active strategies for an energy-efficient, sustainable building environment.
Expected Benefit	This study addresses environmental issues from high energy consumption and carbon emissions. Initially, the Energy Use Intensity (EUI) was 211 kWh/m², which decreased to 87 kWh/m²—a 59% reduction—by leveraging the site's energy potential and integrating advanced facade and mechanical solutions. The Fog Catcher Type A showed a 24% efficiency in absorbing water fog and vapor, significantly improving water collection, especially in winter with nearly 600,000 liters per year. Additionally, implementing clay panels designed with Grasshopper to cover high-radiation surfaces while allowing natural sunlight penetration reduced total peak cooling and heating loads by 31.77%. Starting with a baseline energy use (BAU), the project achieved reductions through facade improvements for heating and cooling (12.11%), better glazing (1.69%), advanced lighting and controls (9.25%), high-efficiency HVAC systems (35.45%), and solar PV panels (44.31%). These combined strategies significantly cut energy consumption, highlighting the effectiveness of integrating passive and active measures for energy efficiency and sustainability. The BROMELIAD LIBRARY project demonstrates a holistic approach to building design, substantially reducing energy usage and contributing to global sustainability goals. The innovative use of fog catchers, clay facades, green walls, and sustainable mechanical systems enhances energy efficiency and helps prevent carbon emissions. The project aims to create a comfortable and environmentally friendly space while preserving valuable resources and enhancing the overall user experience.

No. : **INTL 19**

Works : A Solution for Sustainable Future: Design andFeasibility Analysis of Chemicals based International Renewable Energy Supply Chain

School : National Taiwan University

Department : Chemical Engineering

Advisor : Cheng-Liang Chen / 02-3366-3039 / CCL@ntu.edu.tw

Leader : Chong Wei Ong / 02-3366-3067 / sergeong.ntu@gmail.com

Member : Sheng-Chi Lien Hao-Chu Chang Wei-Te Wang

ITEM	DESCRIPTION
Introduction of Team	Our team is led by Dr. Cheng-Liang Chen, an expert in energy systems and process design. Chong-Wei Ong, a PhD student, is concentrating his research on the global renewable energy supply chain. Meanwhile, Hao-Chu Chang, Wei-Te Wang and Sheng-Chi Lien are the master students and are currently researching process design within the energy sector.
Creation Motive (Problem-solving and technical value)	This proposal presents an international renewable energy supply chain for Taiwan to achieve net-zero carbon emissions by utilizing energy carriers to import renewable energy. This proposal focuses on developing these technologies while comparing the feasibility of different supply chains from an engineering, economic and carbon reduction standpoint.
Research Process	At current stage, an interactive dashboard has been developed to demonstrate the impact of various parameters on the supply chains. This dashboard allows users to adjust parameters such as the cost of renewable electricity from exporters, the efficiencies of water electrolysis and solid oxide fuel cells, shipping distances, and the costs associated with transportation and conversion processes. The interactive dashboard displays comparative results, including imported electricity cost, electricity conversion rate, hydrogen import cost and carbon emissions across different supply chains.
Brief of Work (Creativity/Technical content and feasibility)	To pave the way for a sustainable future, this proposal explores three innovative scenarios for transporting renewable energy to Taiwan: through electricity (**Lithium Batteries**), hydrogen (**metal hydrides, liquefied or compressed**), and chemicals (**H_2, MeOH, NH_3 and MCH**). The comprehensive analysis covers the entire process, from electrolysis to hydrogen fuel cell power generation.
Expected Benefit	By allowing users to manipulate key parameters, the dashboard delivers real-time insights into the economic and environmental impacts of different supply chain configurations. Furthermore, the visualization results in the dashboard facilitates a deeper understanding of how various factors interplay. This comprehensive analysis supports strategic planning and policy-making, optimizing for cost-effectiveness and sustainability.

No. : **INTL 20**

Works : Nanomaterial-driven 'green-heat' generation for CO2-free space-heating and water-desalination

School : Indian Institute of Technology Bombay

Department : Chemistry, Energy Science and Engineering, Mechanical Engineering

Advisor : Sandip K. Saha **/** +91-9930317392 **/** sandip.saha@iitb.ac.in

Team leader : Anuj Bangad **/** +91-9359212094 **/** 21d170006@iitb.ac.in

Member : Nikita Chitre Dipin Thacharakkal C Subramaniam (Advisor)

ITEM	DESCRIPTION
Introduction of Team	**Prof. Sandip Saha:** Expertise in experimental and simulations-based approaches for heat-transfer and thermal technologies. **Prof. C. Subramaniam:** Expertise in experimental nanomaterials and investigating light-matter interactions for energy and environment. **Mr. Anuj Bangad:** 4th years engineering student working on nanomaterials and systems-design for heating and energy storage. **Ms. Nikita Chitre:** 5th year Ph.D. student developing thermally and chemically stable functional coatings. **Mr. Dipin T.:** 5th year Ph.D. student investigating underlying mechanisms for solar-thermal energy conversion.
Creation Motive (Problem-solving and technical value)	Globally, thermal energy is produced predominantly by combustion of non-renewable resources that contributes to 80% of the CO_2 emissions. Our project aims to produce heat and thermal energy without any smoke or CO_2 emissions, by development of highly efficient solar-thermal conversion coatings based on nanocarbons. Such green-heat will significantly mitigate CO_2 emissions and air pollution globally, while promoting the use of sustainable energy.
Research Process	Upon studying the existing literature of broadband black-body absorbers, we observed that vertically aligned carbon nanotube assemblies (VACNTs) exhibited the highest absorption of electromagnetic solar spectrum (250 – 2500 nm). Thereby, we understood that the structural aspect of light absorption is important to realise strong solar-thermal conversion. Accordingly, we took inspiration from this to develop novel nanocarbon florets (NCF) with conical porosity that absorbs 98% of solar spectrum, irrespective of the angle of light incidence. Further, we phonon-engineered the internal structure of NCF to minimize thermal losses and thereby achieve one of the highest solar-thermal conversion efficiency (90%) compared to commercially available coatings (maximum of 65%).

Brief of Work (Creativity/Technical content and feasibility)	Specialized, functional NCF coatings convert sunlight to heat, reaching surface termperatures of upto 150 ^{o}C. The coating works over a wide range of solar concentration ratios from 0.8 – 3.0 SUNS, making it feasible to use under cloudy skies also. The internal of NCF consists of short-range graphetically ordered domains that are intrinsically disordered over the long range. This provides NCF with unique ability to maximize the solar-thermal conversion efficiency and minimize thermal losses. Thus, the heat generated from any NCf-coated surface can be easily transferred to air or water, resulting in energy-efficient, smoke-free space-heating and water-purifying solutions.
Expected Benefit	The two devices that we have developed using NCF-based technology are EcoWarm that delivers energy-efficient, rapid space-heating and SunSpring that delivers pure, potable water at high rate (5-7 $lit.m^{-2}h^{-1}$) through solar-thermal water desalination, while consuming the least energy (0.6 W/lit) among all other approaches (3-10 W/lit). These devices not only save energy, but also realize 15% reduction in global CO_2 emissions. Other applications of these devices extend to process heating in polymer, energy and food processing industries.

作 品 介 紹 ｜ 主 競 賽

Project Introduction

<Main Contest>

編　　號：MAIN 01
作　　品：高效捕捉、轉質再利用及碳材開發技術
學　　校：國立成功大學、東海大學、國立臺灣科技大學、國立臺南大學
系　　所：航空太空工程學系、化學工程與材料工程學系、化學工程系、綠色能源科技學系
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隊　　員：林哲安　林羿同　黃光峻

項目	內容說明
團隊介紹	本團隊是由**國立成功大學**、**東海大學**、**國立臺灣科技大學**、**國立臺南大學**所組成的跨校團隊，團隊主要發展**高效捕捉、轉質再利用及碳材開發技術**。本技術分成四個系統，分別是**高效能捕碳系統**、**微藻固碳系統**、**節能微藻除水技術**、以及生物炭應用於**電池材料**研究，完成前瞻永續碳技術之研發，展現負碳技術、製碳技術及二氧化碳再利用技術之成果。
創作動機 (解決問題與技術價值)	根據環保署最新的統計資料，**臺灣每年 CO_2 排放量約 261 million ton，其排放量位居全世界第 21 名**。為了降低溫室氣體排放量，本團隊有效結合製程強化技術、微藻補碳技術、節能微藻除水及生物炭材電池電極混料配方技術，將所捕獲的 CO_2 封存至鋰電池中，以同時滿足負碳與產能的需求。
創作過程	本團隊發展**高效捕捉、轉質再利用及碳材開發技術**，整合化學吸收與微藻捕碳技術，將大氣二氧化碳進行高效捕捉並再利用至如廢水處理、生物性肥料、鋰電池與塑膠產業等所需之生物炭與生質材料。**超重力旋轉床化學吸收捕碳技術**，可產出具經濟價值之碳酸氫鹽，可作為供給微藻養殖過程之養分。利用**微藻固碳技術**除可回收大氣二氧化碳，並轉質成具經濟價值生物性肥料，亦間接提高衍生加值再利用率。**節能微藻除水技術**可有效降低死亡藻體之乾燥能耗與發霉機率，此外若混入適當綠色添加劑至乾燥藻體，可藉所發展之低溫焙燒技術將其轉質成適用塑膠原料物性之生物炭。同時生物炭亦可進一步藉低耗能熱處理製程與表面修飾技術，可做為**鋰電池**領域一個具發展潛力之負極材料。
作品介紹 (創意、技術內涵與可行性)	本團隊旨在**建立一個完善的碳循環再利用系統**，該系統**以製程強化技術來高效率捕捉工廠排放氣中的 CO_2**，結合微藻補碳技術、節能微藻除水、生物炭材電池電極混料配方技術，將所捕捉之 CO_2 製成生物炭電池電極，創造出一新的生物炭產業供應鏈，完成碳循環再利用的規劃，加速實現 2050 淨零轉型。
預期效益 （預期的節能效率、產值、數據等具體敘述）	**以製備 1 公斤的微藻類生物碳負極為基準，將需要自大氣中捕獲 44.4 公斤的 CO_2**。在考慮各技術機台的電力消耗以及加工處理後，**每生產 1 公斤的生物炭負極材料實際能從大氣中捕獲 7.41 公斤的 CO_2**。與傳統石墨負極相比，**使用 1 公斤的生物炭負極材料取代傳統石墨負極，能夠減少約 39 公斤的產品碳足跡**

No. : MAIN 01

Works : CO_2 Capture and Utilization Technologies

School : National Cheng Kung University, Tunghai University, National Taiwan University of Science and Technology, National University of Tainan

Dept. : Department of aeronautics and astronautics, Department of Chemical and Materials Engineering, Department of Chemical Engineering, Department of greenergy, University center for gybioscience and biotechnolo

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Member : 林哲安 林羿同 黃光峻

ITEM	DESCRIPTION
Introduction of Team	Our team is a cross-university collaboration composed of National Cheng Kung University, Tunghai University, National Taiwan University of Science and Technology, and National University of Tainan. The team primarily focuses on developing technologies for CO_2 capture and utilization. These technologies are divided into four systems: a carbon capture system, a microalgae system, energy-saving drying technology, and biochar application in battery material. The goal is to complete the development of advanced sustainable carbon technologies, showcasing the results of negative carbon technology and CO_2 reutilization technology.
Creation Motive (Problem-solving and technical value)	According to the statistics from the Environmental Protection Administration of Taiwan, the annual CO_2 emissions are approximately 261 million tons, ranking 21st in the world. To reduce greenhouse gas emissions, our team combines these process, carbon capture, microalgae system, energy-saving drying system, and biochar battery electrode mixing technology. The captured CO_2 is sequestered in lithium batteries to simultaneously meet the demands for negative carbon and energy production.

Research Process	Our team develops technologies for CO_2 capture and utilization. We integrate chemical absorption and microalgae system to efficiently capture atmospheric CO_2 and reutilize it in applications such as wastewater treatment, biofertilizers, lithium batteries, and the plastics industry. The rotating bed chemical absorption technology can produce economically valuable bicarbonate, which serves as a nutrient supply for the microalgae cultivation process. The microalgae system not only recovers atmospheric CO_2 but also transforms it into economically valuable biofertilizers, indirectly increasing the reutilization rate of derived value-added products. The energy-saving drying technology effectively reduces the energy consumption and mold risk of drying dead algae. Additionally, by mixing appropriate green additives into the dried algae, the developed low-temperature torrefaction technology can transform it into biochar with physical properties suitable for plastic raw materials. Furthermore, biochar can be further processed through low-energy thermal treatment and surface modification techniques to serve as a potential anode material in the field of lithium batteries.
Brief of Work (Creativity/Technical content and feasibility)	Our team aims to establish a comprehensive carbon recycling and reutilization system. By integrating CO_2 capture system, microalgae system, energy-saving drying technology, and biochar battery electrode mixing technology, the captured CO_2 is converted into biochar battery electrodes. This creates a new type of biochar industry supply chain, completing the planning for carbon recycling and reutilization, and accelerating the realization of the 2050 net-zero transition.
Expected Benefit	Based on the results of analysis, 1 kilogram of microalgae-derived biochar anode, 44.4 kilograms of CO_2 need to be captured from the atmosphere. Considering the power consumption of various technical equipment and processing, each kilogram of biochar anode material can actually capture 7.41 kilograms of CO_2 from the atmosphere. Compared to traditional graphite anodes, using 1 kilogram of biochar anode material instead of traditional graphite anodes can reduce the product's carbon footprint by approximately 39 kilograms.

編　　號：MAIN 02

作　　品：高產率硝酸鹽產綠氨之可產業化膜電極模組-邁向綠氨經濟與碳捕捉之路

學　　校：國立臺灣科技大學

系　　所：材料科學與工程系、能源永續科技研究所

指導教授：郭東昊；0919-914158；dhkuo@mail.ntust.edu.tw

隊　　長：Ha Quoc Nam；0974-063605；namhabc@gmail.com

隊　　員：詹育展　劉冠甫

項目	內容說明
團隊介紹	本團隊來自於國立臺灣科技大學郭東昊教授所指導之材料製程實驗室。目前團隊研究重點係以新穎綠色薄膜技術應用於環境永續的電化學綠氫與綠氨開發為主軸，並結合二氧化碳捕捉來實現綠氨經濟與淨零碳排的效益。
創作動機 (解決問題與技術價值)	以百年歷史的哈伯-博斯製程生產的灰氨，廣泛應用於含氮物，化肥尿素、氫氣載體、燃料等。於此我們開發一種無貴金屬且環保的電催化硝酸鹽還原產綠氨技術(NO_3RR)，並建立工業化模組雛型，朝綠氨經濟跨出一大步。將綠電產之綠氨與空氣捕捉 CO_2 經一次反應生產氮肥與鉀肥，建構獨特負碳排技術。
創作過程	於 2023 年起，國際電催化硝酸鹽產氨出現重大進展，然其產率< 50 mg/h.cm^2。建基於電催化產氫的成果，本實驗室執行綠氨技術研發。我們篩選出 NiFeWO 同為陰極與陽極並製成膜電極電池堆，實現綠氨的高產率(143.5 mg/h.cm^2)、高法拉第效率、低能耗。同時，我們採相同的產氨模組，我們執行兩種 CO_2 捕捉技術：(a) 一次反應法:同步還原 NO_3^- 和 CO_2；(b) 二次反應法:先電化學產氨後再執行 CO_2 捕捉，實現不同碳捕捉技術。
作品介紹 (創意、技術內涵與可行性)	本團隊採用雙功能 NiFeWO 濺鍍薄膜綠色製程，開發電催化硝酸鹽電還原產綠氨，同時第一次展現工業應用所需驗證的產氨單電池堆，施加 2.0 V 時，產氨率達 143.5 mg/h.cm^2，表現出 96.1%的法拉第效率及 26.3 kWh/kg.NH_3 的低能耗，產氨率是所有報導的 3 倍以上。同時提出全球首次的一次反應法，同步執行【硝酸鹽+CO_2 捕捉】電還原，所得產物重 68 mg/ml；反觀二次反應法所得產物重為 30 mg/ml。此作品的實施，說明解決氨經濟，或許是解決 CO_2 碳排的重要負碳排技術。
預期效益 （預期的節能效率、產值、數據等具體敘述）	本作品展示兩項前瞻技術，(1)綠氨技術與(2)綠氨一次反應捕捉 CO_2 產碳酸氫銨/鉀。此濺鍍強固型電極所建立之產氨單電池模組，具長效穩定性，4 cm^2 電極產氨率達 143.5 mg/h.cm^2，於此基礎建立 10 層堆疊 10x10 cm^2 電池堆，一年產氨量可達 1.26 公噸、或捕捉 4.79 公噸 CO_2，產出碳酸氫銨 1.55 公噸與碳酸氫鉀 8.92 公噸。以上產量，可經由模組尺寸與電池堆疊數量調整。

No. : MAIN 02

Works : 高產率硝酸鹽產綠氨之可產業化膜電極模組-邁向綠氨經濟與碳捕捉之路

School : 國立臺灣科技大學

Dept. : 材料科學與工程學系、能源永續科技研究所

Advisor : 郭東昊/ 0919-914158 / dhkuo@mail.ntust.edu.tw

Leader : Ha Quoc Nam / 0974063605 / namhabc@gmail.com

Member : 詹育展　劉冠甫

ITEM	DESCRIPTION
Introduction of Team	Our team is from Professor Dong-Hao Kuo's Materials Processing Laboratory at Taiwan Tech. Currently, our research focuses on the application of novel green thin-film technologies for sustainable electrochemical green H_2 and green NH_3 development, combined with CO_2 capture to achieve the net-zero carbon emissions.
Creation Motive (Problem-solving and technical value)	We have developed a noble-metal-free electrocatalyst for nitrate reduction to green ammonia (NO_3RR) and developed an industrial electrolyzer, making a significant step towards a green ammonia economy. This process integrates green ammonia production using renewable electricity with CO_2 captured from the air, producing nitrogen and potassium fertilizers in a single reaction, demonstrating a unique negative carbon emission technology.
Research Process	We identified NiFeWO as both cathode and anode materials, fabricating membrane electrode cells that achieved high green ammonia yields (143.5 mg/h.cm²), high Faradaic efficiency (FE%), and low energy consumption. Simultaneously, using the same ammonia production module, we designed a CO_2 capture technique i.e., simultaneous reduction of NO_3^- and CO_2
Brief of Work (Creativity/Technical content and feasibility)	We utilizes bifunctional NiFeWO sputtered thin films in a green process to develop electro-catalytic NO_3RR. For the first time, we demonstrate an ammonia production stack- cell meeting industrial application requirement, achieving a production rate of 143.5 mg/h.cm² at 2.0 V, with a FE% of 96.1% and low energy consumption of 26.3 kWh/kg_{NH3}. We also present the world's first one-step reaction method, performing simultaneous reduction of nitrate and CO_2, yielding 68 mg/ml of products. This project exemplifies how addressing the ammonia economy could be an important negative carbon emission technology for mitigating CO_2 emissions.
Expected Benefit	This project showcases two advanced technologies: (1) Green ammonia technology and (2) Green ammonia one-step CO_2 capture to produce NH_4HCO_3/$KHCO_3$. The study sputtered electrodes establish an ammonia production cell electrolyzer with long-term stability. The 4 cm² electrode achieves an ammonia production rate of 143.5 mg/h.cm². Based on this, a 10-layer stack of 10x10 cm² cells can produce 1.26 tons of ammonia per year or capture 4.79 tons of CO_2, producing 1.55 tons of NH_4HCO_3 and 8.92 tons of $KHCO_3$. These outputs can be adjusted by modifying the module size and number of cell stacks.

編　　號：MAIN 03

作　　品：從廢棄到再生：利用回收再生鈣實現碳捕獲與資源化

學　　校：國立中興大學

系　　所：環境工程學系

指導教授：盧明俊；0936415384；mmclu@nchu.edu.tw

隊　　長：黃瀞葳；0988868274；jh153287@gmail.com

隊　　員：呂博揚　陳文榆　侯宣羽

項目	內容說明
團隊介紹	本團隊來自國立中興大學環工系盧明俊特聘教授指導的綠色創新實驗室，團隊主要研究方向為流體化床均質結晶技術，可用於回收水中金屬、非金屬及捕集煙道氣中的二氧化碳。擁有多項專利及在各項大賽獲獎受到各界的肯定，期望能將流體化床均質結晶技術推廣至業界，實現淨零碳排目標。
創作動機 (解決問題與技術價值)	本團隊過去透過二氧化碳吸收槽與流體化床均質結晶技術結合降低煙囪二氧化碳排放量，然而額外添加氫氧化鈉及氫氧化鈣不但會增加操作成本，且會額外增加碳排放量。由於結晶反應系統設計不夠完整，仍會有少部分污泥及廢水產生，吸收槽方面則是需要持續添加額外鹼劑，所以，並沒有保證達到實際減碳排，為此本團隊改良過去系統，因此，新系統無污泥產生，且以焚化飛灰、爐渣或轉爐石等含鈣之廢棄物做為再生資源，透過水洗溶出鈣離子及鹼度，可以實質減碳並創造循環經濟效益。
創作過程	本團隊過去採用鹼劑與二氧化碳反應生成碳酸鹽，並結合流體化床均質結晶技術與再生鈣生成有價產物。為提升本技術實用性，除改良程序外，並利用實廠飛灰及轉爐石回收鈣離子及鹼度。結果顯示，利用水洗法能將轉爐石與飛灰中的鈣離子及鹼度洗出，藉此獲得碳酸鈣結晶粒所需之鈣離子與吸收槽所需之鹼度，並配合實廠化考量以不同鈣/碳酸鹽比例、進流濃度、干擾物做為實驗變因，確認回收再生鈣捕集二氧化碳之可行性。
作品介紹 (創意、技術內涵與可行性)	本技術改良過去使用氫氧化鈣做為鈣源，改以轉爐石及飛灰做為再生鈣源，並回收鹼度至二氧化碳吸收槽使用；透過吸收槽捕捉煙道中二氧化碳，形成碳酸鹽，再導入結晶槽中與鈣離子反應形成碳酸鈣結晶顆粒，不僅可處理工業廢棄物還能減少二氧化碳排放。本技術在常溫常壓下即可操作，具有設備佔地小、操作簡便、安全性高、維修簡易、相容性高、環境友善、節省能源及可擴充等等優點，且產出之結晶顆粒純度高、含水率低，可節省污泥脫水機及乾燥機之操作成本及碳排，且本技術不會因為添加鈣及鹼度而產生額外增加處理費及二氧化碳排放量，可達到實際減碳效益。
預期效益 （預期的節能效率、產值、數據等具體敘述）	先前以氫氧化鈣及氫氧化鈉藥劑時，在最佳條件下，單一結晶槽一年最多可減少 3460 噸的二氧化碳排放，但根據碳排係數計算，此條件下，氫氧化鈣的使用量會產生 9252 噸額外碳排，反而增加碳排放。若使用再生鈣及鹼度，則在回收資源的同時，可實質減少 3460 噸二氧化碳排放量。若與傳統化學沉澱法比較，可節省 6126 噸碳酸鈣污泥脫水碳排量，一年省下約七千萬的污泥處理費。而應用本結晶技術及回收鈣/鹼度，捕集一公斤二氧化碳還可保證獲得 2.61~12.1 元利潤，符合循環經濟之精神。

No. : MAIN 03

Works : From Waste to Renewal: Achieving Carbon Capture and Resource Recovery through Recycled Calcium

School : National Chung Hsing University

Dept. : Environmental Engineering

Advisor : Dr. Ming-Chun Lu / 0936415384 / mmclu@nchu.edu.tw

Leader : Jing-Wei Huang / 0988868274 / jh153287@gmail.com

Member : Po-Yang Lu Wen-Yu Chen Xuan-Yu Hou

ITEM	DESCRIPTION
Introduction of Team	Our team is from the Green Innovation Laboratory, guided by Distinguished Professor Ming-Chun Lu from the Department of Environmental Engineering at National Chung Hsing University. The main research focus of the team is on fluidized bed homogeneous crystallization technology, which can be used to recover metals and non-metals from wastewater and capture carbon dioxide from flue gas. We have obtained multiple patents and won awards in various competitions, receiving recognition from different sectors. We aim to promote the fluidized bed homogeneous crystallization technology to the industry, achieving the goal of net-zero carbon emissions.
Creation Motive (Problem-solving and technical value)	Our team previously used a combination of a carbon dioxide absorption tank and fluidized bed homogeneous crystallization technology to reduce carbon dioxide emissions from flue gas. However, the additional use of sodium hydroxide and calcium hydroxide not only increased operating costs but also added carbon emissions. Due to the incomplete design of the crystallization reaction system, a small amount of sludge and wastewater were still produced, and the absorption tank required continuous addition of extra alkali agents, which did not guarantee actual carbon reduction. Therefore, our team has improved the past system. The new system produces no sludge and uses calcium-containing waste materials such as incineration fly ash, slag, or converter slag as recycled resources. By washing these materials to dissolve calcium ions and alkalinity, the system can achieve substantial carbon reduction and create circular economic benefits.
Research Process	Our team previously used alkali agents to react with carbon dioxide to form carbonates, combining this process with fluidized bed homogeneous crystallization technology and recycled calcium to produce valuable products. To enhance the practicality of this technology, we not only improved the process but also utilized real-world fly ash and converter

	slag to recover calcium ions and alkalinity. Results showed that using a washing method can extract calcium ions and alkalinity from the converter slag and fly ash, providing the necessary calcium ions for calcium carbonate crystallization and alkalinity for the absorption tank. Considering practical application, experiments were conducted with different calcium/carbonate ratios, inlet concentrations, and interferences as variables to confirm the feasibility of using recycled calcium to capture carbon dioxide.
Brief of Work (Creativity/Technical content and feasibility)	This technology improves upon the previous use of calcium hydroxide as a calcium source by utilizing converter slag and fly ash as recycled calcium sources, and it recycles alkalinity back to the carbon dioxide absorption tank for reuse. By capturing carbon dioxide from flue gas in the absorption tank, carbonates are formed, which are then introduced into the crystallization tank to react with calcium ions, forming calcium carbonate crystalline particles. This process not only treats industrial waste but also reduces carbon dioxide emissions. The technology operates at ambient temperature and pressure, featuring a small equipment footprint, simple operation, high safety, easy maintenance, high compatibility, environmental friendliness, energy savings, and scalability. Additionally, the crystalline particles produced are of high purity and low moisture content, reducing the operating costs and carbon emissions of sludge dewatering and drying equipment. This technology does not incur additional treatment costs or carbon emissions due to the addition of calcium and alkalinity, achieving practical carbon reduction benefits.
Expected Benefit	Previously, using calcium hydroxide and sodium hydroxide under optimal conditions, a single crystallization tank could reduce carbon dioxide emissions by up to 3,460 tons per year. However, based on the carbon emission factor calculation, the usage of calcium hydroxide under these conditions would produce an additional 9,252 tons of carbon emissions, resulting in a net increase in carbon emissions. By using recycled calcium and alkalinity, the process can actually reduce carbon dioxide emissions by 3,460 tons while recovering resources. Compared to traditional chemical precipitation methods, this approach can save 6,126 tons of carbon emissions from calcium carbonate sludge dewatering, reducing sludge treatment costs by approximately 70 million NT dollars per year. Furthermore, applying this crystallization technology and recycling calcium/alkalinity can generate a profit of 2.61 to 12.1 NT dollars for

編　　號：MAIN 04
作　　品：四重廢熱回收
學　　校：國立成功大學
系　　所：航空太空工程學系

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項目	內容說明
團隊介紹	為推動淨零排放發展，本團隊由陳維新、池易楷、謝瑞青、汪俊延及林弘萍教授的帶領之下，進行跨校合作(成大、中興、勤益、南大)與技術整合，開發四重廢熱回收系統。期許未來能和世界各地的業者與專家合作推廣，並將研究成果產業化，為淨零排放帶來實質影響，實現地球永續目標。
創作動機 (解決問題與技術價值)	目前工業廢熱中，有 90%左右屬於中、低溫廢熱，其單位能量過低且回收成本較高，因此難以再利用。甲醇蒸汽重組是一種透過化學反應將甲醇蒸汽轉為氫氣之技術，其運作溫度通常在 250-300 °C 之間。焙燒(Torrefaction)是一種前處理技術，能夠在 200-300 °C 之間提高生質物的燃料特性。熱電技術能藉由溫差將熱能直接轉為綠電，且常用於回收中低溫廢熱。有機朗肯循環(Organic rankine cycle, ORC)透過蒸氣的推動，將動能轉為綠電，且蒸氣僅需要 120 °C 以上即可。預熱技術常用於甲醇蒸汽重組，提前預熱流體使系統產氫效率提高。本技術整合焙燒技術、熱電技術、有機朗肯循環及預熱技術，運用工業低溫廢熱進行甲醇蒸汽重組，並回收來自焙燒之廢熱，分別給予熱電、ORC 及預熱系統使用，建立熱循環系統並提高能源使用效率，間接降低產物碳排放量及碳足跡。
創作過程	本團隊回收工業低溫廢熱(300 °C 以下)供給甲醇蒸汽重組作為甲醇水預熱第一重回收，之後進行重組產生氫氣，氫氣可導入焙燒爐進行混氫燃燒，減少化石燃料之使用及降低空氣汙染。焙燒爐在使用過程中，安裝熱交換器回收其廢熱，經過實測熱交換器之出水口蒸汽溫度尚有 140 °C 以上。熱交換器之蒸汽分別通往熱電系統及甲醇水預熱系統，此為第二、三重廢熱回收。熱電系統藉由溫差，能產出綠電提供給工廠內各項設備，或回饋於非熱回收系統中，為能源再利用達到最大化。 提供預熱系統之廢熱經過實測，能有效將甲醇水轉化成蒸汽，並導入甲醇蒸汽重組系統產生氫氣。另外研究過程發現，蒸汽經過熱電系統後，還會有 120 °C 左右之溫度。因此本團隊於後方加入有機朗肯循環系統進一步使用來自焙燒系統之廢熱，此為第四重廢熱回收。
作品介紹 (創意、技術內涵 與可行性)	本團隊所開發之四重廢熱回收系統，再利用工業低溫廢熱，並產出生物炭、綠電及氫氣。本團隊創意點其一在於工業低溫廢熱回收之系統整合，將四項熱回收技術依溫度高低排列，提高廢熱使用效率；其二在於新型熱電晶片材料($Mg_2Sn_{0.7}Si_{0.285}Sb_{0.015}$)開發，其熱電優值(ZT)在 250 °C 可達 1.3；其三在於有機朗肯循環之最大發電量達 1.846 kW；其四，甲醇水預熱與甲醇重組 $CuAl_2O_4$ 觸媒開發，其甲醇轉化率可達 95%以上。
預期效益 (預期的節能效率、產值、數據等具體敘述)	1. 系統整體之低溫廢熱使用效率可達 15%以上。 2. 產出之生物炭水活性低於 0.6，以抑制微生物滋長，提高料源儲存性。 3. 熱電系統於運作過程中，產生 400 W 總功率。 4. 有機朗肯循環之發電量達到 2 kW 以上。 5. 甲醇蒸汽重組之轉化率達到 95%，並且氫氣產率達 2.8 mol·(mol $CH_3OH)^{-1}$。 6. 混氫導入燃燒，降低化石燃料使用與空氣汙染。

No. : MAIN 04

Works : Quadruple Waste Heat Recovery

School : National Cheng Kung University

Dept. : Department of Aeronautics and Astronautics

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Member : Zhi-Xiang Wang　Jun-Yu Guo　Shang-Rong Guo

ITEM	DESCRIPTION
Introduction of Team	To promote the development of net-zero emissions, our team, led by Professors Wei-Hsin Chen, Yi-Kai Chih, Jui-Ching Hsieh, Jun-Yen Uan, and Hong-Ping Lin, is conducting cross-university collaboration (Cheng Kung University, Chung Hsing University, Chin-Yi University of Technology, and Tainan University) and technology integration to develop a Quadruple Waste Heat Recovery System. We hope to collaborate with industry professionals and experts worldwide in the future to promote this technology, industrialize the research outcomes, and make a tangible impact on achieving net-zero emissions, contributing to the sustainable development goals of our planet.
Creation Motive (Problem-solving and technical value)	Currently, about 90% of industrial waste heat is classified as medium- and low-temperature waste heat, which has low energy density and high recovery costs, making it difficult to reuse. Methanol steam reforming is a technology that converts methanol steam into hydrogen through chemical reactions, typically operating at temperatures between 250-300°C. Torrefaction is a pre-treatment technique that enhances the fuel characteristics of biomass at temperatures between 200-300°C. Thermoelectric technology can directly convert heat into green electricity through temperature differences and is commonly used to recover medium- and low-temperature waste heat. The Organic Rankine Cycle (ORC) converts kinetic energy into green electricity using steam, requiring temperatures of only above 120°C. Preheating technology is often used in methanol steam reforming, where preheating the fluid improves the system's hydrogen production efficiency. This technology integrates torrefaction, thermoelectric generation, ORC, and preheating technology to utilize industrial low-temperature waste heat for methanol steam reforming, while also recovering waste heat from torrefaction for use in thermoelectric, ORC, and preheating systems. This establishes a thermal cycle system and improves energy utilization efficiency, indirectly reducing the carbon emissions and carbon footprint of the products.

Research Process	Our team recovers industrial low-temperature waste heat (below 300°C) and utilizes it for methanol steam reforming as the first stage of waste heat recovery, preheating the methanol-water mixture. After reforming, hydrogen is produced, which can be fed into the torrefaction furnace for hydrogen-enriched combustion, reducing the use of fossil fuels and lowering air pollution. During the operation of the torrefaction furnace, a heat exchanger is installed to recover its waste heat. Tests show that the steam temperature at the outlet of the heat exchanger remains above 140°C. The steam from the heat exchanger is directed to both the thermoelectric system and the methanol-water preheating system, constituting the second and third stages of waste heat recovery. The thermoelectric system, by utilizing the temperature difference, generates green electricity that can be used by various equipment in the factory or fed back into non-heat recovery systems, maximizing energy reuse. Tests have shown that the waste heat provided to the preheating system effectively converts the methanol-water mixture into steam, which is then fed into the methanol steam reforming system to produce hydrogen. Furthermore, our research revealed that after passing through the thermoelectric system, the steam still retains a temperature of around 120°C. Therefore, our team has incorporated an Organic Rankine Cycle system to further utilize the waste heat from the torrefaction system, marking the fourth stage of waste heat recovery.
Brief of Work (Creativity/Technical content and feasibility)	Our team has developed a Quadruple Waste Heat Recovery System that reuses industrial low-temperature waste heat to produce biochar, green electricity, and hydrogen. The first innovation of our system lies in the integration of industrial low-temperature waste heat recovery technologies, where the four heat recovery techniques are arranged according to temperature levels to maximize the efficiency of waste heat utilization. The second innovation is the development of a new thermoelectric material ($Mg_2Sn_{0.7}Si_{0.285}Sb_{0.015}$) with a thermoelectric figure of merit (ZT) reaching 1.3 at 250°C. The third innovation is achieving a maximum power output of 1.846 kW with the Organic Rankine Cycle. Finally, the fourth innovation involves the development of a methanol-water preheating system and a $CuAl_2O_4$ catalyst for methanol reforming, achieving a methanol conversion rate of over 95%.
Expected Benefit	1. The overall low-temperature waste heat utilization efficiency of the system can reach over 15%. 2. The produced biochar has a water activity below 0.6, which inhibits microbial growth and enhances the storage stability of the feedstock. 3. The thermoelectric system generates a total power output of 400 W during operation. 4. The Organic Rankine Cycle achieves a power output of over 2 kW. 5. The methanol steam reforming process reaches a conversion rate of 95%, with a hydrogen yield of 2.8 mol·(mol $CH_3OH)^{-1}$ 6. The introduction of hydrogen-enriched combustion reduces fossil fuel usage and air pollution.

編　　號：MAIN 05

作　　品：基於工業 4.2-綠色智慧製造(I4.2-GiM)框架之節能減碳調節(ESCRA)系統

學　　校：國立成功大學

系　　所：製造資訊與系統研究所、生物科技中心、智慧製造研究中心、環境工程學系

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隊　　員：黃容羽

項目	內容說明
團隊介紹	本團隊來自於國立成功大學，團隊主要致力於推進台灣製造業實現 2050 淨零碳排(Net Zero)的目標。我們通過結合智慧製造、微藻科技、和環境永續的知識與技術，來應對當前製造業的環境與經濟挑戰。
創作動機 (解決問題與技術價值)	製造業是台灣的經濟命脈也是主要之碳排放源。現行節能減碳措施效果有限，所以急須研發共具節能與減碳效益的系統化方法。本研究旨在改善我國淨零碳排表現，提出一套具系統化的負碳技術政策建議。本研究採用 I4.2-GiM 和 ESCRA 兩系統：I4.2-GiM 系統具備在不影響產能和良率的條件下進行優化工廠能源管理之能力；ESCRA 系統則具備實現智慧微藻養殖以進行生物固碳之能力。本全方位解決方案可協助製造業實現聯合國淨零碳排之目標，並可做為我國擬定碳交易政策之參考。
創作過程	目前市面上的各式能源管理、碳排管理、和智慧製造等系統，大都是獨立運作的模組，致未能有效一併整合碳排管理、能源管理、和智慧製造等功能，導致在複雜的製造業營運模式中難以實現全方位的節能與減碳效果。另一方面，台灣將自然碳匯列為淨零碳排(Net Zero)之關鍵策略，其中的微藻固碳因其具備高效率之特性，所以被列為重要選項；但目前微藻固碳面臨標準化不足、系統化方法欠缺、和碳排量化困難等挑戰，所以急須研發創新解決方案來推動其發展和政策落實。
作品介紹 (創意、技術內涵與可行性)	I4.2-GiM 為工廠進行節能減碳的生產排程、廠務調節、與電力調配，盡可能減少工廠的碳排放。剩餘的碳排放量則由 I4.2-GiM 向 ESCRA 提出「碳排放消弭」需求，是為碳排減量的需求端。ESCRA 則提供直接固碳技術之碳中和手段，是為碳減量供給端，與碳減量需求端相互平衡，推進 2050 年前達到淨零碳排(Net Zero)的國際趨勢。
預期效益 （預期的節能效率、產值、數據等具體敘述）	本作品中 I4.2-GiM 系統的微電網經過有效的生產排程調度和廠務設備調控，使全天實際的能源消耗減少約 10.09%；碳排放量減少約 12.56%。另外 I4.2-GiM 與 ESCRA 系統整合，除了有助於優化養殖過程並提高整體減碳效益，我們也針對國際能源總署的目標，計劃與長榮航空合作，透過微藻轉酯化技術生產生質油，其可製為永續航空燃料(SAF)，也能產出生質燃料供汽電共生廠取代部分化石燃料做使用，以減少碳排放。

No. : MAIN 05

Works : Industry 4.2 - Green Intelligent Manufacturing Framework (I4.2-GiM) for Energy Saving and Carbon Reduction Adjustment (ESCRA) System

School : National Cheng Kung University

Dept. : Institute of Manufacturing Information and Systems, University Center for Bioscience and Biotechnology, Intelligent Manufacturing Research Center, and Department of Environmental Engineering

Advisor : Hao Tieng
Chun-Yen Chen
Fan-Tien Cheng

Leader : Yu-Tzu Fan

Member : Rong-Yu Huang

ITEM :	DESCRIPTION
Introduction of Team	Our team is from National Cheng Kung University and is primarily dedicated to achieving Net Zero in Taiwan's manufacturing industry by 2050. We address the current environmental and economic challenges in the manufacturing industry by integrating knowledge and technologies in intelligent manufacturing, microalgae technology, and environmental sustainability.
Creation Motive (Problem-solving and technical value)	Although Taiwan's manufacturing industry has a global foothold, it is a major carbon emitter due to direct and indirect emissions. Independent energy-saving and carbon-reduction efforts have yielded limited results in recent years. To tackle these issues and enhance Taiwan's performance in international Net Zero, the I4.2-GiM and ESCRA systems have been developed.
Research Process	The various energy management, carbon emission management, and intelligent manufacturing systems available on the market operate as independent modules. This lack of integration has hindered the effective unification of carbon emission management, energy management, and intelligent manufacturing functions, making it challenging to achieve comprehensive energy-saving and carbon-reduction effects within the complex operational modes of the manufacturing industry. Additionally, Taiwan has identified natural carbon sinks as a critical strategy for

	achieving Net Zero emissions. Among these, microalgae carbon sequestration is regarded as a significant option due to its high efficiency. However, it currently faces challenges such as insufficient standardization, lack of systematic methodologies, and difficulties in quantifying carbon emissions. Therefore, there is an urgent need to develop innovative solutions to advance its development and facilitate policy implementation.
Brief of Work (Creativity/Technical content and feasibility)	I4.2-GiM manages production scheduling, plant regulation, and power allocation for factories to achieve energy saving and carbon reduction, aiming to minimize both direct and indirect carbon emissions from the factory. The remaining carbon emissions are addressed by I4.2-GiM through requesting for "carbon emission elimination" from ESCRA, taking the demand role of carbon reduction. On the other hand, ESCRA provides direct carbon sequestration technology, representing the supply side of carbon reduction. The balance between the carbon reduction demand and supply advances the international trend of achieving Net Zero carbon emissions by 2050.
Expected Benefit	In this work, the I4.2-GiM system's microgrid effectively reduces actual daily energy consumption by approximately 10.09% and carbon emissions by approximately 12.56% through efficient production scheduling and facility equipment adjustments. Additionally, the integration of the I4.2-GiM system with the ESCRA system not only helps optimize the cultivation process and enhance overall carbon reduction benefits but also aligns with the International Energy Agency's goals. We plan to collaborate with EVA Air to produce bio-oil through microalgae transesterification technology, which can be used to create Sustainable Aviation Fuel (SAF). The biofuel can also supply cogeneration plants to replace a portion of fossil fuels, thereby reducing carbon emissions.

編　　號：MAIN 06

作　　品：合成低碳雙金屬催化劑處理有機廢水之節能與創新應用

學　　校：國立中興大學

系　　所：環境工程學系

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隊　　長：陳映妤；0968923221；yingyu0221@gmail.com

隊　　員：陳政曜　李驊恩

項目	內容說明
團隊介紹	本團隊來自國立中興大學環工系盧明俊特聘教授指導的綠色創新實驗室，團隊主要研究方向為水及廢水高級氧化處理技術與流體化床均質結晶技術，用於回收水中金屬及非金屬資源。擁有多項專利及在各項大賽獲獎受到各界的肯定，期望能將高級氧化及結晶技術推廣至業界，實現淨零碳排目標。
創作動機 (解決問題與技術價值)	芬頓氧化技術處理廢水效率非常高，但是缺點是需在低 pH 下反應及產生大量鐵污泥。本研究旨在開發及合成可在中性 pH 值下使用的新型雙金屬催化劑，並進一步可通過流體化床技術從廢水中回收重金屬，合成有用之催化劑。因為廢水重金屬成分複雜，所以結晶粒會有直接回收再利用之困難，而製作成催化劑則是可行的方案之一，高科技產業中經常有含銅、鎳及鐵等金屬之廢水，因此有潛力可回收做為催化劑使用，我們將這些結晶顆粒應用於芬頓氧化技術，可改善該技術的局限和缺點。
創作過程	本技術以流體化床均質結晶技術(FBHC)透過成核與晶體成長兩個過程形成純度高達 95%和含水率達 5%的結晶顆粒，而 FBHC 產出的顆粒容易回收，因此，可做為雙金屬催化劑用以降解污染物，以催化劑催化過氧化氫產生自由基，與有機污染物發生反應而降解之。為提升本技術之降解效率，以不同污染物濃度、催化劑用量、pH 值、氧化劑劑量為操作變因，尋求最佳雙金屬顆粒合成之條件。
作品介紹 (創意、技術內涵與可行性)	本研究以流體化床結晶技術透過成核與晶體成長兩個過程形成結晶顆粒，其優勢在於能夠在常溫常壓下進行，合成可在中性pH值下使用的新型Cu-Fe、Ni-Fe 和 Co-Fe 雙金屬催化劑。這些固體催化劑的優點有結構穩定、不易溶於水、具有較大表面積和多孔結構，能在中性 pH 條件下有效反應，且可以重複使用多次。故能減少酸與鹼劑的使用及污泥量的減少，並能突破芬頓程序必須在酸性條件下的限制，將廢棄物轉化為有價值資源。
預期效益 （預期的節能效率、產值、數據等具體敘述）	以每日 3000 噸 COD 為 360 mg/L 的染整廢水，處理至 80 mg/L 為例，每單位 COD 需要的 2.125 倍的理論過氧化氫量、亞鐵與過氧化氫的莫爾比為 1:10，而鐵污泥的處理成本為每噸 12,000 元。每月約可節省 67 萬元的鐵污泥處理費。而在酸鹼藥劑成本方面，每月可節省 77,780 元，若依酸鹼劑碳排係數計算，則得知每月減少 24,913 公斤二氧化碳排放。含污泥處理費及藥劑費，每月可省 747,780 元，平均去除每公斤 COD 總共節省 288 元及減少排放 1.15 kg CO_2。

No. : MAIN 06

Works : Energy Saving and Innovative Applications of Synthetic Low-Carbon Bimetallic Catalysts for Treatment of Organic Wastewater

School : National Chung Hsing University

Dept. : Department of Environmental Engineering

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Member : Chen, Cheng-Yao Li, Hua-En

ITEM :	DESCRIPTION
Introduction of Team	Our team is from the Green Innovation Laboratory, supervised by Distinguished Professor Ming-Chun Lu of the Department of Environmental Engineering at National Chung Hsing University. The team's primary research focuses are advanced oxidation processes for water and wastewater treatment and fluidized bed homogeneous crystallization technology for the recovery of metallic and non-metallic resources from water. We hold multiple patents and have received numerous awards in various competitions, earning recognition from different sectors. We aim to promote advanced oxidation and crystallization technologies in the industry to achieve the goal of net-zero carbon emissions.
Creation Motive (Problem-solving and technical value)	Fenton oxidation technology is highly efficient for wastewater treatment, but its drawbacks include the need for reactions to occur at low pH levels and the generation of a large amount of iron sludge. This study aimed to develop and synthesize novel bimetallic catalysts that can operate at neutral pH levels. Furthermore, these catalysts can be produced by recovering heavy metals from wastewater through fluidized bed technology, synthesizing useful catalysts in the process. Due to the complex composition of heavy metals in wastewater, directly recycling crystallized particles can be challenging. However, transforming them into catalysts is a feasible solution. Wastewater from high-tech industries often contains metals such as copper, nickel, and iron, which have the potential to be recycled and used as catalysts. By applying these crystallized particles in Fenton oxidation technology, we can overcome the limitations and drawbacks of the current technology.

Research Process	This study employed fluidized bed crystallization technology to form crystalline particles through nucleation and crystal growth processes. The advantage of this method is its ability to operate at ambient temperature and pressure, synthesizing novel Cu-Fe, Ni-Fe, and Co-Fe bimetallic catalysts that can be used at neutral pH levels. These solid catalysts were characterized by their structural stability, low solubility in water, large surface area, and porous structure. They can effectively react under neutral pH conditions and be reused multiple times. This reduces the need for acids and bases, decreases sludge production, and allows for the repeated use of the catalysts. As a result, it overcomes the limitation of the Fenton process requiring acidic conditions and converts waste into valuable metal resources, achieving resource recycling.
Brief of Work (Creativity/Technical content and feasibility)	This study utilized fluidized bed crystallization technology to form crystalline particles through the processes of nucleation and crystal growth. The advantage of this method lies in its ability to operate at ambient temperature and pressure, synthesizing novel Cu-Fe, Ni-Fe, and Co-Fe bimetallic catalysts that can be used at neutral pH levels. These solid catalysts possess several advantages, including structural stability, low solubility in water, a large surface area, and a porous structure. They can effectively react under neutral pH conditions and can be reused multiple times. This reduces the use of acids and bases, decreases sludge production, and allows for repeated reuse. As a result, it overcomes the limitation of the Fenton process, which requires acidic conditions, and converts waste into valuable metal resources, achieving resource recycling.
Expected Benefit	For textile wastewater of 3000 CMD with COD of 360 mg/L, treated to 80 mg/L, the theoretical amount of hydrogen peroxide required per unit COD is 2.125 times, with a molar ratio of ferrous ion to hydrogen peroxide of 1:10. The treatment cost for iron sludge is 12,000 TWD per ton. It shows that approximately 670,000 TWD can be saved monthly in iron sludge treatment costs. In terms of saving on acid and alkali reagent costs, 77,780 TWD can be saved monthly, and based on the carbon emission coefficient of acid and alkali reagents, it is estimated that carbon dioxide emissions are reduced by 24,913 kilograms per month. On average, the removal of each kilogram of COD saves a total of 288 TWD and reduces carbon emissions by 1.15 kg CO_2.

編　　號：MAIN 07

作　　品：有害廢棄物之高值化再利用

學　　校：國立中興大學

系　　所：材料科學與工程學系、循環經濟研究學院半導體與綠色科技學程、循環經濟研究學院工業與智慧科技學位學程

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隊　　長：羅紹峰；0961227398；frank.luo02@gmail.com

隊　　員：沈峻名　蔡啓春　洪右任　陳鈺澤　莊尉程　李珈瑜　蘇俊安

項目	內容說明
團隊介紹	此項技術是由四位教授所共同研發，其中吳威德特聘教授主要負責鋁渣市場調查與特性分析，劉凡瑋助理教授負責尋找低成本回收高金屬 Al 原料的方法，並透過林啓明助理教授進行電爐試驗與造渣劑優化，最後，試驗後的有害氣體的捕捉與分析則是由林家吟助理教授完成。 本項高效率去化鋁渣之技術也榮獲相當多的肯定，如在環境部主辦之大專綠色化學競賽獲得銀獎、112 年度的環工年會獲得傑出論文獎。
創作動機 (解決問題與技術價值)	台灣每年預估將產出 9 萬公噸的鋁渣廢棄物，其中所含有的 AlN 遇水會產生氨(NH_3)臭味，而鋁渣的處理成本高(36 元/kg)，導致鋁渣非法掩埋與堆置之環境危害，而台灣尚無低成本且高效率去化技術。
創作過程	本團隊構思一可商業化大量穩定去化鋁渣的運作模式，只要將鋁渣投入煉鋼環境下將其轉變為氧化礎，即可達成鋁渣去化與循環再利用之目的。本團隊將根據實驗室級試驗之結果，總結出具備最佳爐渣性質之 Al_2O_3 成分範圍。並透過與台灣各地之鋼廠合作機會，利用現場之電爐進行鋁渣去化試驗，並計算出爐渣之節能效益與最大鋁渣去化量。
作品介紹 (創意、技術內涵與可行性)	由 100 公噸級電弧爐試驗結果證實，在鋁渣添加量為 8~16.5 kg/ton 下，其冶煉平均電力輸出為 381 kWh/ton，相近於傳統製程之 385 kWh/ton，並達到鋁渣最大去化量 16.5 kg/ton 的成效，而添加鋁渣複合劑之製程，可利用鋁渣複合劑與 FeO 鋁熱反應，可使電力消耗降低至 299 kWh/ton steel，節能效益可達 22.4%，且本團隊創造優異性質之發泡渣，可使噴碳量可從 11 kg /ton steel 降低至 7.35kg /ton steel，噴碳量減少了 31.8%，最終的製程成本可減少 428 元/ton steel。
預期效益 （預期的節能效率、產值、數據等具體敘述）	僅添加鋁渣之節能效益不顯著，卻能夠達到大量去化鋁渣(16.5 kg/ton steel)之目標，而添加鋁渣複合劑之節能效益顯著(-22.4%)、減碳效益明顯(-31.8%)，也能夠達到去化鋁渣(5.6 kg/ton steel)之目標。若全台的電爐廠在製程中採用本技術，鋁渣每年最大去化量可達 11.6 萬噸，可以達到完全去化鋁渣之目標，本技術可以達到循環經濟、降低碳排、減少電爐製程成本、增加產品附加價值與減少鋁渣處理成本等目的。

No. ：**MAIN 07**

Works ：High-value reuse of hazardous aluminum dross

School ：National Chung Hsing University

Dept. ：Department of Material Science & Engineering, Academy of Circular Economy

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Leader ：Shao-Feng Luo / 0961227398 / frank.luo02@gmail.com

Member ：Jyun-Ming Shen　Chi-Chun Tsai　Yo-Zeng Hong　Yu-Ze Chen　Wei-Cheng Chuang　Jia-Yu Lee　Jun-An Su

ITEM	Description
Introduction of Team	This technology was jointly developed by four professors. Among them, Professor Wu is primarily responsible for aluminum dross market research and characteristic analysis. Assistant Professor Liu focuses on finding low-cost methods for recycling high-metal aluminum raw materials. Assistant Professor Lin conducts electric furnace tests and optimizes slagging agents. Finally, Assistant Professor Lin is responsible for capturing and analyzing harmful gases after the tests. This high-efficiency aluminum dross removal technology has also received significant recognition, including a silver medal at the College Green Chemistry Competition sponsored by the Ministry of Environment and the Outstanding Paper Award at the 35th Annual Environmental Engineering Conference.
Creation Motive (Problem-solving and technical value)	There is 90,000 metric tons of aluminum dross have been produced in Taiwan each year. The AlN (aluminum nitride) contained in it releases ammonia (NH_3) odors when exposed to water. The processing cost of aluminum dross is high, at 36 NTD per kilogram, which contributes to its illegal disposal. Burying and stacking aluminum dross pose environmental hazards, and Taiwan currently lacks low-cost and efficient technologies for its removal.

Research Process	Our team has developed an operational model to commercialize the stable treatment of large quantities of aluminum dross. By introducing aluminum dross into a steelmaking environment and converting it into oxide slag, we can effectively achieve aluminum dross removal and recycling. Based on laboratory tests, we will determine the optimal Al_2O_3 composition range for the best slag properties. Through collaborations with steel mills across Taiwan, we have conducted on-site electric furnace tests for aluminum dross removal and calculated the associated energy savings and the maximum removal capacity.
Brief of Work (Creativity/Technical content and feasibility)	The test results from the 100-ton electric arc furnace confirm that when the amount of aluminum dross added ranges from 8 to 16.5 kg/ton, the average power consumption for smelting is 381 kWh/ton. This is close to the 385 kWh/ton required by traditional processes, and the maximum aluminum dross removal achieved is 16.5 kg/ton. By using the aluminum dross composite agent in combination with FeO thermite, power consumption can be reduced to 299 kWh/ton of steel, yielding an energy savings benefit of 22.4%. Additionally, the foamed slag developed by our team has excellent properties, reducing carbon injection from 11 kg/ton of steel to 7.35 kg/ton of steel, which is a 31.8% reduction. This reduction in carbon injection lowers the final processing cost by 428 NTD per ton of steel.
Expected Benefit	Adding aluminum dross alone does not provide significant energy savings but effectively removes a substantial amount of aluminum dross (16.5 kg/ton of steel). In contrast, using the aluminum dross composite agent offers substantial benefits, with a 22.4% reduction in energy consumption and a notable 31.8% reduction in carbon injection. This method can achieve an aluminum dross removal rate of 5.6 kg/ton of steel. If all electric furnace plants in Taiwan adopt this technology, the annual aluminum dross removal could reach up to 116,000 tons, potentially achieving complete aluminum dross removal. This technology supports a circular economy, reduces carbon emissions, lowers electric furnace process costs, enhances product value, and decreases aluminum dross processing expenses.

編　　號：**MAIN 08**

作　　品：Magnetic Flywheel Energy Storage System with Low Energy Consumption

學　　校：Nation Chung Cheng University

系　　所：Department of Mechanical Engineering

指導教授：陳世樂；0910393243；imeslc@ccu.edu.tw

隊　　長：林敬翔；0960593368；sammy8571@yahoo.com.tw

隊　　員：魏碩池　王聖鈞

項目	內容說明
團隊介紹	我們來自國立中正大學機械工程學系陳世樂博士之研究團隊，本團隊長期致力於磁浮軸承研究，近期著重在飛輪儲能系統的開發，朝向淨零碳排的目標看齊，本團隊之專長包括主/被動磁浮軸承之設計、自動控制。本團隊亦有開發飛輪儲能系統、磁力聯軸器之經驗。
創作動機 (解決問題與技術價值)	磁浮飛輪儲能系統有其優勢，如無磨耗、長壽、高輸出功率。然而該系統有兩個主要問題。第一，磁浮需要額外耗費能量、第二，運轉過程產生之熱堆積可能影響懸浮。本團隊設計一全新之磁浮飛輪儲能系統，可解決上述兩個問題，強化磁浮飛輪儲能技術之實用性。
創作過程	1. 本團隊利用特殊設計之磁浮軸承，使得系統在懸浮過程僅需極少的能量。 2. 這些特殊設計包括: 被動式磁浮軸承、混合式磁浮軸承。透過部分使用永久磁鐵，懸浮所需能量得以被降到最低。 3. 本團隊系統採用特殊架構，將熱源集中於散熱良好處，以避免不必要之熱堆積。 4. 然而此架構需處理力量傳遞問題，本團隊利用磁力聯軸器解決該問題。
作品介紹 (創意、技術內涵與可行性)	1. 被動式磁浮軸承由永久磁鐵組成，且永久磁鐵採海爾貝克陣列之方式排列，以最大化磁浮之力量。如此一來可以在不耗費能量的情況下使系統懸浮。 2. 然而僅由永久磁鐵所構成之系統無法穩定懸浮，因此混合式磁浮軸承肩負使系統穩定懸浮的角色需透過控制混合式磁浮軸承以完全懸浮飛輪。而相關控制法則之設計為本團隊之專長。 3. 混合式磁浮軸承透過電磁鐵與永久磁鐵的結合，使其僅需花費很少的能量便可達成懸浮。 4. 磁力聯軸器之設計為解決熱堆積為題的核心技術。本團隊有開發磁力聯軸器之經驗。
預期效益 （預期的節能效率、產值、數據等具體敘述）	本團隊提出一全新磁浮飛輪儲能系統之原型，以解決耗能及熱堆積之問題。由於磁浮所需之能量被大幅降低，因此可以預期有更高的能量轉換效率。另外，由於熱堆積之問題被解決，可以預期系統運作變得更穩定、提供更高的運轉極限。此外，更好的散熱效率意味著可以減少原先散熱設備之體積、成本。

No. : MAIN 08

Works : Magnetic Flywheel Energy Storage System with Low Energy Consumption

School : Nation Chung Cheng University

Dept. : Department of Mechanical Engineering

Advisor : Shyh-Leh, Chen / 0910393243 / imeslc@ccu.edu.tw

Leader : Jing Siang, Lin / 0960593368 / sammy8571@yahoo.com.tw

Member : Shuo Chih, Wei Sheng Jyun, Wang

ITEM :	DESCRIPTION
Introduction of Team	We come from Dr. Shyh-Leh Chen's research team in the Department of Mechanical Engineering at National Chung Cheng University. Our team has been dedicated to the research of magnetic bearings, and more recently, we have been focusing on the development of flywheel energy storage systems towards the goal of net-zero carbon emissions, and our team's specialties include the design of active/passive magnetic bearings, and automatic controls.
Creation Motive (Problem-solving and technical value)	The magnetic flywheel energy storage system has its advantages such as no wear and tear, long life, and high output power. However, there are two major problems with the system. Firstly, magnetic levitation requires additional energy. And secondly, the heat accumulation generated during the operation may affect the levitation. Our team has designed a new magnetic flywheel energy storage system to solve the above two problems and to enhance the practicality of the levitation flywheel energy storage technology.
Research Process	1. The team utilizes a specially designed magnetic bearing, which allows the system to require very little energy during the levitation process. 2. However, a system composed of permanent magnets alone cannot stabilize levitation, so the hybrid magnetic bearing plays the role of stabilizing the system by controlling the hybrid magnetic bearing to fully levitate the flywheel. The design of the related control law is the specialty of our team. 3. Hybrid magnetic bearings levitate with very little energy by combining an electromagnet with a permanent magnet. 4. The design of magnetic coupler is the core technology to solve the problem of heat accumulation. Our team has experience in developing magnetic couplers. **(More information via QR code)**

編　　號：MAIN 09

作　　品：綠色材料應用於能源技術開發 :光熱海綿達成綠電淨水的生產

學　　校：國立臺灣大學

系　　所：化學工程所

指導教授：童國倫；02-23635230；E-mail：kltung@ntu.edu.tw

隊　　長：葉佾叡；0909484590；D11524016@ntu.edu.tw

隊　　員：林佳宏　陳劭宇

項目	內容說明
團隊介紹	(黃河之水天 Sun 來) 本團隊由台灣大學學生 2023 年組合而成，由不同背景的組員進行配合。創業內容以大自然啟發之綠色微電漿系統製程出水筆仔衍生結構海綿進行太陽能自身驅動來達到雙能源(水和電)的製造。在一年內，獲得產、官、學、研的肯定，榮獲 2024 教育部氣候變遷競賽實作競賽 佳作暨環境部最佳氣候變遷調適能力獎、海委會/AIT 國際青年海洋論壇 青年組第一名及最佳創新獎、科技部化學工程學門研討會 英文口頭特優以及科技部國際材料研討會 海報特優等等，透過源源不絕的太陽光活水得注入，創造綠電淨水，讓台灣好山好水。
創作動機 (解決問題與技術價值)	隨著全球暖化問題的加劇，淡水資源和能源供應的需求明顯已經失去了平衡。單靠節水已無法解決問題。因此，產官學研開始關注如何「開源」，以取得更豐富且穩定的水資源供應。傳統的海水淡化技術雖然有效，但成本高昂且能耗巨大。因此我們轉向自然尋求解決方案，希望通過模仿水筆仔的自然過濾機制，開發出一種既環保又經濟的海水淡化及發電新技術。
創作過程	我們的核心動機是模擬水筆仔的自然濾水過程，開發一種可持續且高效的海水淡化和發電系統。利用水筆仔根部的結構特點，我們研發出一種新型的海綿材料。E-sponge tech 不僅能高效進行海水淡化，而且在這一過程中，通過光熱轉換離子濃度差原理產生電力，實現了雙重目標，達到經濟、環境及社會效益。
作品介紹 (創意、技術內涵與可行性)	生質能海綿製造與優化：(電漿系統建置大面積以塑膠及生質能海綿) -材料特性：具有高太陽吸收率、抗鹽結垢能力和良好的電導性。 -海綿結構優化：設計多孔結構，以提高蒸發效率和淡水產量。 =使用無毒、短時間及低成本(約台幣 10 元即可製造 1m^2 積)製程技術，減緩生質能廢棄物，增加新能源。 太陽光熱蒸發器效能測試 (淡水河)：(3D 立方體系統設計搭配海綿材料) -海綿蒸發器串聯與系統集成：增加淡水產量 (~5LMHB)、電力產生(~5V) -長時間測試：真實太陽條件下進行運行，評估系統的穩定性和持久性。 -效能監控：建立效能監控系統，分析淡水產量、電力輸出等數據。 =結合自然太陽光與綿延不絕的海水純化為 WHO 合格的飲用及電力。
預期效益 (預期的節能效率、產值、數據等具體敘述)	E-sponge 技術則大幅降低了能耗和成本，與 RO 進行相比：降低 100%的電力，創造出 1000%的水量，並可創造出綠能，能達到 2050 的減碳要求，將有助於氣候變遷減緩並落實循環經濟及氣候正義。

No. : MAIN 09

Works : Photothermal Sponge Achieves Green Electricity and Water Purification Production

School : National Taiwan University (NTU)

Dept. : ChE.

Advisor : Kuo-Lun Tung / 02-23635230 / kltung@ntu.edu.tw

Leader : Yi-Jui Yeh / 0909484590 / D11524016@ntu.edu.tw

Member : Chia-Hung Lin Shao-Yu Chen

ITEM :	DESCRIPTION
Introduction of Team	Our team of National Taiwan University students, formed in 2023, developed a nature-inspired green microplasma system to create photothermal sponges for solar-powered dual production of water and electricity. Within a year, we received significant recognition, including an Honorable Mention in the 2024 Ministry of Education Climate Change Competition, the Best Climate Change Adaptation Award from the Ministry of Environment, First Place and Best Innovation Award in the Ocean Affairs Council/AIT International Youth Ocean Forum, and top honors in presentations at Ministry of Science and Technology conferences.
Creation Motive (Problem-solving and technical value)	As global warming intensifies, the demand for freshwater resources and energy supply has clearly become imbalanced. Simply conserving water is no longer a viable solution. Therefore, industry, government, academia, and research institutions are focusing on "sourcing" to achieve a richer and more stable water supply. Traditional seawater desalination techniques, though effective, are costly and energy-intensive. Consequently, we have turned to nature for solutions, aiming to develop an environmentally friendly and economical new technology for seawater desalination and power generation by mimicking the natural filtration mechanism of mangroves.
Research Process	Our core motivation is to mimic the natural water filtration process of mangroves to develop a sustainable and efficient seawater desalination and power generation system. Utilizing the structural features of mangrove roots, we have developed a novel sponge material. The E-sponge technology not only efficiently desalinates seawater but also generates electricity through photothermal ion concentration difference during this process, achieving dual goals and providing economic, environmental, and social benefits.
Brief of Work (Creativity/Technical content and feasibility)	**Manufacturing and Optimization of Bioenergy Sponge:** **(Plasma System for Large-Scale Production with Plastic and Bioenergy Sponge)** -Material Characteristics: High solar absorption rate, salt resistance, and

	good electrical conductivity. -Sponge Structure Optimization: Designed with a porous structure to enhance evaporation efficiency and freshwater yield. = Utilizing a non-toxic, short-duration, and low-cost (about 10 TWD to produce 1m²) process technology, it reduces bioenergy waste and increases new energy. **Performance Testing of Solar Photothermal Evaporator (Danshui River): (3D Cubic System Design with Sponge Material)** -Sponge Evaporator Series and System Integration: Increases freshwater yield (~5L per hour), electricity generation (~5V). -Long-Term Testing: Operated under real sunlight conditions to evaluate the system's stability and durability. -Performance Monitoring: Establish a performance monitoring system to analyze data on freshwater yield, electricity output, etc. = Combining natural sunlight with continuous seawater purification to produce WHO-compliant drinking water and electricity.
Expected Benefit	The E-sponge technology significantly reduces energy consumption and costs compared to RO systems: it reduces electricity usage by 100%, produces 1000% more water, and generates green energy, meeting the carbon reduction requirements for 2050. This technology will help mitigate climate change and promote a circular economy and climate justice.

編　　號：MAIN 10

作　　品：稀有磁理 - 創新低碳回收純化技術

學　　校：國立清華大學

系　　所：材料科學工程學系

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項目	內容說明
團隊介紹	本團隊來自國立清華大學材料系賴志煌教授帶領的先進儲存與能源實驗室，主要研究領域涵蓋：低功耗磁性儲存元件、薄膜太陽能電池、鋰電池與稀土磁鐵回收等符合永續發展與低碳能源的題目，期望結合團隊在材料分析、製程優化、純化技術的專長，協助我國達成資源循環與淨零轉型。
創作動機 (解決問題與技術價值)	在國際淨零碳排與潔淨能源轉型的趨勢下，電動車與風力發電的急速發展使得稀土元素的需求增長，預估至 2040 年將增長 7 倍，其中釹鐵硼磁鐵因為優越性能已被大量應用於同步馬達及相關工業產品，然而傳統高汙染的開採方式未來將不再適用，因此稀土回收再生成為滿足市場需求的關鍵。本團隊開發一新型電化學技術，能夠將稀土元素以稀土複合物型式與其他雜質分離，除了簡化回收流程、滿足低碳趨勢、提供低碳原料，更有機會藉由團隊磁性分析的專長，讓再生稀土材料再直接應用到磁鐵的製造鏈。
創作過程	釹鐵硼磁鐵回收傳統方法包括：火法冶金、濕法冶金和電化學冶金，其中火法處理量大但耗能高，濕法純度高但廢液污染嚴重，電化學則能以電位差原理，使不同元素能以電化學溶解或氧化的方式分離，因此具有更快的反應速率以及較低的能源與溶劑消耗。團隊開發新型電化學技術，擷取濕法冶金高純度以及電化學高效率的優點，並透過配方參數控制與模擬產物預測實現選擇性分離，將釹鐵硼磁鐵中的稀土元素以純度超過 99%的稀土複合氧化物形式回收，大幅製程效率並符合低碳永續目標。
作品介紹 (創意、技術內涵與可行性)	稀土元素因其獨特性質，被廣泛應用於磁鐵、電池、雷射等工業領域，被譽為「工業維他命」。然而，個別稀土難以分離且純化過程污染嚴重，且全球稀土資源主要掌握在少數國家。團隊針對釹鐵硼磁鐵的回收與純化，開發新型電化學技術，能有效提純稀土元素至 99%以上，並顯著降低化學品與能源消耗，有望實現稀土的低碳回收。
預期效益 （預期的節能效率、產值、數據等具體敘述）	以生產相同重量與純度的稀土氧化物而言，團隊開發的創新電化學技術對比傳統方法，能一步驟提純並獲得純度 99%以上的產物，且化學品可循環使用，耗能僅 15 千瓦時，相較選礦的 80 千瓦時和火法冶金的 500 千瓦時，節能效益提升 5 至 30 倍，且設備投資小，適合產業應用。此技術不僅減少碳排放，還有助於提升台灣關鍵原料的自主能力，完善產業供應鏈。

No. : MAIN 10

Works : Rare Earth Magnets - Innovative Low Carbon Recycling and Purification Technology

School : National Tsing Hua University

Dept. : Materials Science and Engineering

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Leader : Shao-Chi Lo / 03-5715131 #33863 / 0938278967 / shaochilo@gmail.com

Member : Jing-Yin Lin Ting-Huan Chiu

ITEM :	DESCRIPTION
Introduction of Team	Our team is from the Advanced Storage and Energy Laboratory, led by Professor Chih-Huang Lai from MSE department, NTHU. Our primary research fields include low-power magnetic storage devices, thin-film solar cells, and the recycling of lithium-ion batteries as well as rare earth magnets. We aim to leverage our expertise in material analysis, process optimization, and purification techniques to support our society in achieving resource sustainability and net-zero transition.
Creation Motive (Problem-solving and technical value)	In the trend towards international net-zero carbon emissions and clean energy transition, the rapid development of electric vehicles and wind power has led to a significant increase in demand for rare earth elements, which is estimated to grow sevenfold by 2040. Neodymium-iron-boron (NdFeB) magnets, known for their superior performance in synchronous motors and related industrial products, are extensively used. However, traditional high-pollution mining methods are no longer sustainable. Therefore, recycling of rare earth resources has become crucial to meet market demands. Our team has developed an innovative electrochemical technology capable of separating rare earth elements in the form of solid compounds from impurities. This not only simplifies the recycling process and aligns with net-zero trends by providing low-carbon raw materials, but also utilizes our team's expertise in magnetic analysis to reintegrate recycled rare earth materials directly into magnet manufacturing supply chains.
Research Process	Traditional methodologies for recycling NdFeB magnets include pyrometallurgy, hydrometallurgy, and electrometallurgy. Pyrometallurgy handles large volumes but is energy-intensive; hydrometallurgy achieves

	high purity but causes significant liquid waste pollution. Electrometallurgy, based on potential difference principles, allows elements to be separated through electrochemical dissolution or oxidation, resulting in faster reaction rates and lower energy and solvent consumption. Our team has developed an innovative electrochemical technology that combine experimental observation with thermodynamic simulation to achieve selective separation. This approach successfully recovers rare earth elements from NdFeB magnets into oxides compounds with over 99% purity. The time-consuming, energy-intensive, and high-pollution drawbacks of conventional recycling methods are much improved by enhancing process efficiency.
Brief of Work (Creativity/Technical content and feasibility)	Thanks to unique properties, rare earth elements are widely used in industrial products such as magnets, batteries, and lasers, earning the nickname "vitamins of industry". However, rare earth elements are difficult to be separated individually, and the purification process is heavily polluting. Moreover, global rare earth minerals are primarily controlled by a few countries. Our team has developed an innovative electrochemical technology for the recycling NdFeB magnets. This approach effectively recovers rare earth elements to over 99% purity while significantly reducing chemical and energy consumption, aiming to be used as low-carbon resources.
Expected Benefit	For producing the same weight and purity of rare earth oxides, our innovative electrochemical approach can achieve product purity over 99% in one step. Besides, chemicals are recyclable and energy consumption is only 15 kWh. Compared to 80 kWh for beneficiation and 500 kWh for pyrometallurgy, our method represents 5 to 30 times improvement in energy efficiency, with lower equipment investment, making it suitable for industrial applications. This work not only reduces process carbon emissions but also enhance the industrial supply chain of critical materials in Taiwan.

編　　號：MAIN 11

作　　品：實現淨零碳排：打造生物廢水處理技術革新突破

學　　校：國立成功大學

系　　所：環境工程學系

指導教授：吳哲宏；0910385159；enewujh@mail.ncku.edu.tw

隊　　長：林宜庭；0983298297；f54106030@gs.ncku.edu.tw

隊　　員：馮禮君　邵勇先　莊函音　陳杉樺

項目	內容說明
團隊介紹	本團隊來自於國立成功大學環境工程學系，由吳哲宏教授帶領的微生物功能與技術實驗室。本團隊發展新世代永續生物除氮技術，透過精準控制微生物體使污水處理能兼顧污染物去除與永續，邁向新世代的污水處理。
創作動機 (解決問題與技術價值)	氮污染是目前的嚴峻挑戰。現行的污水生物處理技術除氮的同時卻消耗大量電力與化學藥劑、產生廢棄污泥、並排放溫室氣體 N_2O 及 CO_2，使得污水處理在去除氮污染的同時，卻對環境造成二次污染。本團隊結合分硝化/厭氧銨氧化程序(PN/A)、膜曝氣生物膜反應槽(MABR)與 UF 膜，透過膜曝氣精準控制微生物體，發展兼顧高效除氮與永續新世代生物除氮技術。
創作過程	PN/A 在一反應槽中透過曝氣控制，使好氧的氨氧化菌與厭氧的厭氧銨氧化菌合作除氮。過往認為 PN/A 程序因曝氣控制與菌群培養困難，而難以實際應用於污水處理。本團隊透過深入探討不同功能菌群特性發展快速培養及控制菌群反應之操作策略。結合 MABR-UF，使 PN/A 菌群大量生長於曝氣膜表面。並透過曝氣膜以間歇曝氣方式精準控制氧氣，使好氧的部分硝化與厭氧的厭氧銨氧化反應能在單一反應槽中合作以處理銨氮污水。
作品介紹 (創意、技術內涵與可行性)	本團隊首先發展一快速啟動 PN/A 反應槽策略，使得曝氣膜表面附著生長大量生物膜，氨氧化菌於生物膜內側靠近曝氣膜表面，而厭氧銨氧化菌位於生物膜外側易於攝取污水中的氮污染物。獨特的功能菌群空間分布造成氧氣與氮污染反向擴散，形成空間上的低溶氧-缺氧環境。此外，我們以曝氣膜進行間歇曝氣，創造時間上的低溶氧-缺氧環境。時間與空間上的雙重控制使得好氧與厭氧反應在 PN/A-MABR-UF 中同時發生。進一步測試顯示，PN/A-MABR-UF 能穩定高效處理處理工業銨氮廢水。
預期效益 （預期的節能效率、產值、數據等具體敘述）	因其獨特的除氮路徑與微生物特性，PN/A 除氮耗能 1.5 kWh/kg-N，相較於傳統的污水生物除氮技術(15 kWh/kg-N)減少 90%，產生的廢棄污泥量減少>80%，甲醇添加量減少 100%。顯示本團隊發展之 PN/A-MABR-UF 能高效除氮同時符合節能減碳，邁向淨零碳排之永續污水處理場。此外，本套系統特有的模組化設計與智能控制，在未來小型場域的應用上具有相當的優勢。科學園區、小型工廠、休閒農場等，也可能是 PN/A-MABR-UF 的應用場域，節省污水管線配置與輸送所需耗費的能源又能將廢水妥善處理而不傷害環境，使污水處理系統更加完善。

No. : MAIN 11

Works : Achieving Net-Zero: Breakthrough in Biological Wastewater Treatment

School : National Cheng Kung University

Dept. : Environmental Engineering

Advisor : Jer-Horng Wu / 0910385159 / enewujh@mail.ncku.edu.tw

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Member : Li-Jin Fong Yung-Hsien Shao Han-Yin Chuang Shan-Hua Chen

ITEM :	DESCRIPTION
Introduction of Team	Our team hails from the Department of Environmental Engineering at National Cheng Kung University and is led by Professor Che-Hong Wu in the Microbial Function and Technology Laboratory. We aim to achieve efficient pollutant removal while ensuring sustainability, paving the way for the future of wastewater treatment.
Creation Motive (Problem-solving and technical value)	Nitrogen pollution is a severe challenge today. Current biological wastewater treatment technologies remove nitrogen but consume large amounts of electricity and chemicals, generate waste sludge, and emit greenhouse gases. Our team integrates Partial Nitritation/Anammox (PN/A), Membrane Aerated Biofilm Reactors (MABR), and UF membranes. The PN/A-MABR-UF system is shown to remove nitrogen efficiently and sustainably, serving as a breakthrough in biological nitrogen removal technologies.
Research Process	PN/A processes have been considered difficult to apply in wastewater treatment due to the challenges in the aeration control and cultivation of functional microbial populations. Our team has developed strategies for rapid cultivation and control of microbial communities. The PN/A-MABR-UF system enables extensive growth of PN/A populations on the surface of the aeration membrane. Intermittent aeration through the membrane allows precise oxygen control, facilitating the cooperation of aerobic partial nitritation and anaerobic anammox reaction within a single reactor to treat ammonium wastewater.
Brief of Work (Creativity/Technical content and feasibility)	Our team first developed a rapid startup strategy for the PN/A reactor, enabling the growth of a thick biofilm on the surface of the aeration membrane. Ammonia-oxidizing bacteria reside on the inner side of the biofilm, close to the aeration membrane surface, while anaerobic ammonium-oxidizing bacteria are located on the outer side of the biofilm.

	Additionally, temporal microaerobic-anoxic environments are created by intermittent aeration through the aeration membrane. Together, the spatial and temporal control dissolved oxygen conditions ensure simultaneously aerobic and anaerobic reactions in the PN/A-MABR-UF system, which has been shown to stably and efficiently treat industrial ammonium wastewater in subsequent tests.
Expected Benefit	PN/A-MABR-UF removes nitrogen from wastewater in an efficient and sustainable manner. For nitrogen removal, PN/A-MABR-UF consumes 1.5 kWh/kg-N, a 90% reduction compared to traditional biological nitrogen removal technologies (15 kWh/kg-N). Additionally, it reduces waste sludge production by over 80% and eliminates the need for methanol addition. This demonstrates that the PN/A-MABR-UF system developed by our team can efficiently remove nitrogen while meeting energy-saving and carbon reduction goals, paving the way for net-zero in wastewater treatment. Furthermore, the system's modular design and intelligent control offer significant advantages for future applications in small-scale settings. Potential application sites include science parks, small factories, and leisure farms, which would benefit from reduced energy consumption for wastewater piping and transportation.

編　　號：MAIN 12

作　　品：PGME 製程鹼性廢液嗜鹼性菌族群生物處理及負碳效益評估

學　　校：國立中興大學

系　　所：環境工程學系

指導教授：吳向宸；0910763158；wusc@nchu.edu.tw

隊　　長：陳建丞；0905154323；s4110063016@smail.nchu.edu.tw

隊　　員：鄭宇閑　曾苡禎

項目	內容說明
團隊介紹	本團隊來自於國立中興大學環工系吳向宸教授帶領的「環境分子微生物實驗室」，致力於研究嗜鹼性菌於 PGME 製程分餾鹼性廢液之生物處理可行性，並針對未來運用在實廠操作及嗜鹼性菌負碳能力的效益評估，希望透過此研究以尋求 PGME 製程廢液的新興去化策略，整合 2050 淨零碳排願景促進 PGME 產線永續發展與減碳循環的目標。
創作動機 (解決問題與技術價值)	丙二醇單甲醚（PGME），傳統產業用於染料、油墨等溶劑，近年來也大量作為清洗半導體晶圓邊緣的光阻稀釋劑。在生產的同時容易產生許多副分餾不純物，使得排放廢水具有 COD 過高的問題 。為解決此現象，我們選擇使用在高鹼度和高 pH 環境中具有生長優勢的嗜鹼性異營菌族群，透過植種於 PGME 製程分餾鹼性廢液的降解馴養測試，優選具廢鹼液有機物降解效果的嗜鹼性族群。另外，也逐步自微生物群集中分離單一純菌並測試其降解。除有活躍於強鹼廢水環境之優勢外，強鹼性廢液也同時具有加速二氧化碳吸收之碳捕捉特性。本研究創作動機為，透過生物處理高 COD 強鹼廢水的同時，評估強鹼廢水處理時之碳捕捉潛力，期望可降低 PGME 之產品碳足跡，有利提升半導體製程之節能減碳。
創作過程	1. 鹼性土壤樣品採樣：針對嘉義、彰化沿海地區鹼性土壤探查採樣作為環境嗜鹼性異營菌族群之來源。 2. 含廢水培養基馴養：架設多個組別以僅含廢水為營養來源之培養基觀察 COD 下降情形。 3. SBR 反應槽處理：建立 SBR 反應槽進行大量廢水連續降解處理測試。 4. 純菌分離：於廢水培養基及 SBR 反應槽兩種處理單元進行稀釋抹碟以分離出單一純菌，進行純菌於固態廢水培養基之生長測試。 5. 純菌降解能力測試：測試分離之單一純菌降解 COD 能力，並以不同初始 COD 濃度進行比較。 6. 強鹼廢水碳捕捉能力測試 (不含菌與含菌)：密閉瓶頂注入模擬煙道尾氣之氣態二氧化碳，觀察強鹼廢液於生物處理過程之碳捕捉效益。
作品介紹 (創意、技術內涵 與可行性)	高 COD 強鹼廢水過去並未有以生物處理之前例，傳統活性污泥廢水處理多為嗜中性菌種，本研究率先由臺灣本土鹼性土壤作為植種來源，測試嗜鹼性族群於鹼性廢水之有機物降解能力。嗜鹼性菌之培養環境和條件與一般中性菌差異甚大，且分離純化之使用技術也相對不同，而本研究透過次世代定序技術先行了解對 PGME 製程分餾強鹼廢水中有機物降解有利之嗜鹼性菌族群，也於族群中以篩選性培養技術分離出純嗜鹼性菌種，有利於未來降解機制研究與工程應用之推展。此外，本研究整合 2050 淨零碳排之發展趨勢，以密閉瓶搭配二氧化碳即時感測器之特製試驗裝置，投入了解強鹼廢水生物處理之碳捕捉潛力。
預期效益 （預期的節能效率、產值、數據等具體敘述）	預期可產生 PGME 分餾鹼性廢液之生物處理 COD 去除效益、具可應用於強鹼廢水處理之嗜鹼性菌優勢族群類別、取得具未來可投入機制與工程實務化之純嗜鹼性菌種、了解強鹼廢水生物處理過程中之氣態二氧化碳捕捉潛力(以大氣二氧化碳百分比及吸收通量作為效益評估指標)。

No. : MAIN 12

Works : Biological Treatment of Alkaline Wastewater from PGME Processes Using Alkaliphilic Bacterial Communities and Carbon Negative Benefits Evaluation

School : National Chung Hsing University

Dept. : Environmental Engineering

Advisor : Dr.Siang-Chen Wu / 0910763158 / wusc@nchu.edu.tw

Leader : Chien-Cheng Chen / 0905154323 / s4110063016@smail.nchu.edu.tw

Member : Yu-Hsien Cheng Yi-Chen Tseng

ITEM :	DESCRIPTION
Introduction of Team	Our team originates from Professor Hsiang-Chen Wu's "Environmental Molecular Microbiology Laboratory" at National Chung Hsing University. We are dedicated to researching the feasibility of alkaliphilic bacteria in the biotreatment of alkaline wastewater from PGME (possibly a specific industrial process), with a focus on future application in industrial operations and assessing the carbon-negative potential of alkaliphilic bacteria. Through this research, we aim to explore emerging treatment strategies for PGME wastewater, integrating with the 2050 net-zero carbon emissions vision to promote sustainable development and carbon reduction cycles in PGME production lines.
Creation Motive (Problem-solving and technical value)	Propylene Glycol Monomethyl Ether (PGME) is traditionally used as a solvent in industries such as dyes and inks. In recent years, it has also been extensively used as a photoresist thinner for cleaning the edges of semiconductor wafers. The production process often leads to numerous by-products and impurities, resulting in wastewater with excessively high Chemical Oxygen Demand (COD). To address this issue, we chose to use alkaliphilic heterotrophic bacterial communities, which thrive in high alkalinity and high pH environments. Through degradation and acclimation tests using these bacteria in alkaline wastewater from the PGME production process, we selected the most effective alkaliphilic strains for organic waste degradation. Additionally, we isolated and tested individual pure strains from microbial communities for their degradation capabilities. Besides their advantage in handling strongly alkaline wastewater, these alkaline wastewaters also have carbon capture properties, accelerating CO2 absorption. The motivation for this study is to evaluate the carbon capture potential during the biological treatment of high COD strong alkaline wastewater, aiming to reduce the carbon footprint of PGME products and enhance energy efficiency and carbon reduction in semiconductor processes.

Research Process	1. Alkaline Soil Sample Collection: Alkaline soil samples will be collected from coastal areas in Chiayi and Changhua as sources for alkaliphilic heterotrophic microbial communities in the environment. 2. Wastewater Medium Cultivation: Multiple experimental groups will be set up using only wastewater as a nutrient source to observe the decrease in COD. 3. Sequencing batch reactor (SBR) Treatment: Establishing SBR reactors to conduct continuous degradation tests on large volumes of wastewater. 4. Pure Strains Isolation: Dilution plating will be performed in both wastewater medium and SBR reactors to isolate individual pure cultures. Growth tests of pure cultures will be conducted on solid wastewater media. 5. Degradation Ability Testing of Pure Strains: Evaluate the COD degradation ability of isolated pure strains and compare performance across different initial COD concentrations. 6. Testing of Alkaline Wastewater Carbon Capture Capability (with and without bacteria): Gas-phase carbon dioxide simulating flue gas will be injected into sealed bottles to observe the carbon capture efficiency during the biological treatment of alkaline wastewater.
Brief of Work (Creativity/Technical content and feasibility)	The research described breaks new ground by addressing the challenge of high COD alkaline wastewater through biological treatment, which has not been previously explored. Traditional wastewater treatment with activated sludge primarily involves neutrophilic bacteria. This study pioneers the use of native alkaline soils from Taiwan as a source for seeding alkaliphilic microbial communities to test their ability to degrade organic compounds in alkaline wastewater. Alkaliphilic bacteria require significantly different cultivation environments and conditions compared to neutrophilic bacteria. The techniques for their isolation and purification are also considerably different. This research utilizes next-generation sequencing technology to initially identify alkaliphilic microbial communities beneficial for degrading organic compounds in alkaline wastewater from PGME distillation processes. Selective cultivation techniques are then employed to isolate pure strains of alkaliphilic bacteria from these communities, facilitating further research into degradation mechanisms and engineering applications. Moreover, the study integrates with the 2050 net-zero carbon emissions development trend. It involves custom experimental setups with sealed bottles equipped with real-time CO_2 sensors to investigate the carbon capture potential of biological treatment of alkaline wastewater. This approach aims to advance understanding and potential applications of biological processes in mitigating carbon emissions associated with industrial activities.
Expected Benefit	Expected outcomes include efficient COD removal through biological treatment of PGME alkaline waste, identification of predominant alkaliphilic bacterial communities applicable to strong alkaline wastewater treatment, acquisition of pure alkaliphilic bacterial strains suitable for future deployment and engineering practices, and assessment of CO_2 capture potential during biological treatment of strong alkaline wastewater (using atmospheric CO_2 percentage and absorption flux as performance indicators).

編　　號：MAIN 13

作　　品：全自動產水　太陽光驅動產水自供電水凝膠之循環應用

學　　校：國立台灣大學

系　　所：材料科學與工程學系、化學工程學系

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隊　　員：王鈺皓　蕭力維　林羿萱

項目	內容說明
團隊介紹	本團隊由國立台灣大學材料系的劉振良老師、羅世強老師，以及化工系的康敦彥老師，及各老師的學生們所組成，透過結合來自不同實驗室的技術來合力完成這項研究。 希望透過結合各實驗室專長來開發出以太陽能驅動的產水裝置，促進綠能科技發展以及水資源循環。
創作動機 (解決問題與技術價值)	為了解決全球能源危機以及淡水資源稀缺的問題，本團隊開發結合光熱發電以及光驅動產水技術的水凝膠，水凝膠作為具有交聯親水網絡的三維聚合物，由於聚合物主鏈具有許多親水性基團，吸水性能非常優異，不僅如此，透過摻雜不同的氧化還原對或無機鹽類，也可以使水凝膠具有優異的導電度，透過結合熱電以及光熱水凝膠來做為能夠自供電產水的循環應用。
創作過程	此研究選擇聚乙烯醇(PVA)作為水凝膠網路，作為光熱和熱電材料的基材。在 PVA 中加入三氧化二鈦奈米顆粒以及奈米碳管分散液。上述兩者作為光熱材料，用於提升太陽能水蒸發以及光熱轉換能力，並在後續結果中展現出優異的水蒸發速率和光熱轉換效率，使裝置在太陽光照射下能夠快速且有效地進行水蒸發。在熱電水凝膠方面，將 PVA 浸泡於氧化還原對溶液中，利用 Thermogalvanic 效應，在水凝膠的冷熱端分別進行還原及氧化反應來提供電壓。此裝置在溫差驅動下產生的電壓能夠為小型電子設備供電，實現熱電轉換的功能。最終將兩種元件結合成太陽能自供電水凝膠產水裝置。
作品介紹 (創意、技術內涵與可行性)	本團隊利用光熱以及熱電水凝膠整合成單一元件用於自供電循環產水之應用，特點在於水凝膠本身為對環境十分友善的材料，光熱水凝膠能夠大幅淡水純化的速率，熱電水凝膠則能巧妙的利用太陽能來進行發電驅動抽水馬達等裝置，達到自供電循環之目的，我們團隊希望可以透過發展此種綠能裝置來避免過度依賴傳統高耗能的海水淡化技術，減低碳排放量。
預期效益 （預期的節能效率、產值、數據等具體敘述）	若將實驗室規模的光熱水凝膠放大至平方公尺的尺度大小，每小時將能蒸發純化出約 2 kg 的淡水，在自供電系統方面若能串聯 100 個熱電水凝膠，可以產生接近 1.5 V 的電壓，若串聯數目足夠，將可以啟動抽水馬達等等較大功率的元件，利用抽水馬達確保海水充足，持續產生純水，達到自供電不斷循環的目的。

No. : MAIN 13

Works : Fully Automated Water Production: Solar-Powered, Self-Sustaining Hydrog
Generation and Cyclic Application

School : National Taiwan University

Dept. : Materials Science and Engineering / Chemical Engineering

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Leader : Cheng-Yuan Lin / 0902306188 / h0979461469@gmail.com

Member : Yu-Hao Wang Li Wei Hsiao Yi-Hsuan Lin

ITEM :	DESCRIPTION
Introduction of Team	Our team includes Professors Cheng-Liang Liu and Shyh-Chyang Luo from Materials Science and Engineering, and Professor Dun-Yen Kang from Chemical Engineering at National Taiwan University, along with their students.
Creation Motive (Problem-solving and technical value)	Due to the global energy crisis and freshwater scarcity, our team is developing a hydrogel that integrates photothermal electricity generation and solar-driven water production. This research combines thermoelectric and photothermal hydrogels for self-sustaining water production and cyclic applications.
Research Process	This research uses polyvinyl alcohol (PVA) as the hydrogel network for photothermal and thermoelectric applications. Incorporating titanium dioxide (TiO_2) nanoparticles and carbon nanotubes into PVA enhances solar water evaporation and photothermal efficiency. For the thermoelectric hydrogel, PVA is immersed in a redox pair solution, generating voltage through thermogalvanic reactions at the cold and hot ends.
Brief of Work (Creativity/Technical content and feasibility)	The photothermal hydrogel accelerates freshwater purification rates, while the thermoelectric hydrogel uses solar energy to power devices such as water pumps, achieving a self-powered cycle. By developing this green technology, we aim to reduce reliance on traditional energy-intensive desalination methods and decrease carbon emissions.
Expected Benefit	Scaling the photothermal hydrogel to a square meter can purify about 2 k of freshwater per hour. Connecting 100 thermoelectric hydrogels in serie generates nearly 1.5 V, powering devices like water pumps and enablin a self-sustaining water supply and purification cycle.

編　　號：MAIN 14
作　　品：金屬燃燒應用之淨零碳排動力系統
學　　校：國立成功大學
系　　所：航太系、工科系、能源系
指導教授：李約亨　陳文立；0982604045；yueheng@mail.ncku.edu.tw
隊　　長：林伯鴻；0976670287；lwianyy@gmail.com
隊　　員：王彥儒　Le Minh Tam　李苑萱

項目	內容說明
團隊介紹	本團隊隸屬於國立成功大學航太系，由陳文立教授和李約亨教授指導，專注於零碳燃料燃燒技術的研究與開發。我們主要探索鐵作為替代或補充化石燃料的低碳能源載體的可行性，並致力於將這項技術與史特林引擎結合，開發無碳發電系統。
創作動機 (解決問題與技術價值)	世界各地的可再生能源生產量正創歷史新高。隨著可再生能源發電容量的日益增長，投資可再生能源發電的商業案例也不斷增多。然而，由於能源需求和供應之間在時間和空間上的差異，需要儲存和運輸大量的能源。因此，對於易於儲存和運輸的能源載體的需求正在增加。鐵在這方面非常有潛力，特別是在綠色金屬燃料經濟的背景下，被建議用於固定發電或供熱。鐵具有穩定性高、豐富性、體積能量密度高、毒性低、市場價格低等優勢，並且已有完善的生產基礎設施和運輸網絡支持。在高溫氧化時，鐵燃燒產生的熱量與傳統固體燃料相似，但不釋放 CO_2。其燃燒產物是固態的氧化鐵，易於收集和回收。氧化鐵可以通過還原氣體（如氫氣）還原回純鐵，實現循環利用。
創作過程	為了實現低碳能源技術，我們專注於開發以鐵作為燃料的燃燒系統。 使用鐵粉作為燃料進行燃燒存在著多項挑戰和難度。首先，鐵粉的燃燒反應需要較高的點火溫度，這使得點燃和穩定燃燒過程變得困難。此外，由於燃燒速度遠低於氣態燃料，使用鐵粉燃燒時會出現火焰傳播速度過慢的現象。這種現象導致燃燒區域的火焰傳播延遲，使得整體燃燒過程較為緩慢且不均勻。火焰傳播速度慢會影響燃燒的穩定性，增加了局部熄火的風險，特別是在燃燒器內部氣流動態複雜的情況下。以及由於鐵粉的顆粒小且質量較大，在燃燒過程中容易沉降，難以保持均勻的懸浮和充分的氧氣供應，這可能導致燃燒不完全。燃燒過程中生成的氧化鐵會形成氧化層，進一步影響燃燒效率。為了克服上述問題，我們首先設計了一個能夠有效燃燒鐵粉的燃燒器設計來確保均勻的分布和充分的氧氣混合，並測試其燃燒效率和穩定性。在成功穩定鐵粉火焰後，我們結合史特林引擎進行實驗，測試燃燒產生的熱能轉換為電能的效果。燃燒過程中產生的氧化鐵粉末與高溫空氣會在排放至大氣前被分離與收集，以確保其可回收性。回收後方可透過氫氣等還原氣體將氧化鐵還原為鐵粉，從而實現完整的循環。
作品介紹 (創意、技術內涵 與可行性)	本團隊的鐵燃燒系統是一項創新技術，旨在以鐵作為替代燃料來減少碳排放。系統利用鐵粉的燃燒來產生能量，並且將燃燒產物氧化鐵透過還原反應再生為鐵粉，實現燃料的循環使用。創意方面，本系統不僅在能源轉換過程中不釋放 CO_2，還能利用高溫燃燒產生的熱量來驅動史特林引擎進行發電。此外，燃燒過程中的氧化鐵產物為固態，易於收集和再生，避免了傳統燃燒過程中廢氣處理的困難。此外，鐵作為燃料來源豐富且價格低廉，具備實際應用的潛力，為工業和發電領域提供了一種具競爭力的無碳能源解決方案。
預期效益 （預期的節能效率、產值、數據等具體敘述）	在此技術成熟且能夠大規模取代燃煤的前提下，假設台灣一年煤的消耗量為 5000 萬噸（50 Mt），若用鐵燃燒系統替代其中的 10%，即 500 萬噸（5 Mt）的煤，可顯著減少碳排放。煤燃燒每噸排放約 3.67 噸 CO_2，因此 500 萬噸煤的碳排放量約為 1835 萬噸 CO_2。而鐵燃燒不釋放 CO_2，每產生 1 kWh 電力可節省 917 g CO_2，取代這些煤燃燒後可減少 1835 萬噸的 CO_2排放。這展示了鐵燃燒系統在大規模應用中的減碳潛力，並為未來的淨零排放目標提供了可行的解決方案。目前本團隊的技術尚處於實驗室等級的開發階段，未來主要發展方向之一是以產生蒸氣為主，預期熱效率可達 30%。

No. ：MAIN 14

Works ：Net Zero Carbon Power Systems through Metal Combustion Applications

School ：National Cheng Kung Unerversity

Dept. ：DAA、ES、IBDPE

Advisor ：Chen, Wen-Lih、Li, Yueh-Heng / 06-2757575 ext. 63632 / yueheng@mail.ncku.edu.tw

Leader ：Lin, Po-Hung / 0976670287 / lwianyy@gmail.com

Member ：Wang, Yan-Ru　Le Minh Tam　Lee,Yuan-Hsuan

ITEM：	Description
Introduction of Team	Our team is affiliated with the Department of Aeronautics and Astronautics at National Cheng Kung University, under the guidance of Professor Wen-Li Chen and Professor Yuheng Lee. We focus on the research and development of zero-carbon fuel combustion technology. Our primary exploration involves the feasibility of using iron as an alternative or supplementary low-carbon energy carrier to fossil fuels. Additionally, we are dedicated to integrating this technology with Stirling engines to develop a carbon-free power generation system.
Creation Motive (Problem-solving and technical value)	Renewable energy production is reaching record highs worldwide. As the capacity for renewable energy generation continues to grow, there are increasing commercial cases for investing in renewable energy power generation. However, due to the temporal and spatial differences between energy demand and supply, there is a need to store and transport large amounts of energy. This has led to an increasing demand for energy carriers that are easy to store and transport. Iron shows great potential in this regard, especially in the context of a green metal fuel economy. It is suggested for use in stationary power generation or heating. Iron has several advantages, including high stability, abundance, high volumetric energy density, low toxicity, low market price, and well-established production infrastructure and transportation networks. When oxidized at high temperatures, iron releases heat comparable to that of traditional solid fuels but without CO_2 emissions. Its combustion product is solid iron oxide, which is easy to collect and recycle. The iron oxide can be reduced back to pure iron using reducing gases like hydrogen, enabling circular utilization.

Research Process	To achieve low-carbon energy technology, we focus on developing a combustion system that uses iron as fuel. However, there are several challenges and difficulties associated with using iron powder as a fuel. Firstly, the combustion reaction of iron powder requires a high ignition temperature, making it difficult to ignite and maintain a stable combustion process. Additionally, due to the slower combustion rate compared to gaseous fuels, iron powder combustion exhibits a slow flame propagation speed. This phenomenon results in delayed flame propagation in the combustion zone, making the overall combustion process slower and less uniform. The slow flame propagation speed affects combustion stability, increasing the risk of local flame extinction, especially in complex airflow dynamics within the combustor. Moreover, due to the small particle size and relatively high mass of iron powder, it tends to settle during combustion, making it challenging to maintain uniform suspension and adequate oxygen supply, which may lead to incomplete combustion. The formation of an oxide layer during the combustion process further impacts combustion efficiency. To overcome these issues, we have designed a combustor capable of effectively burning iron powder, ensuring uniform distribution and adequate oxygen mixing. We tested its combustion efficiency and stability. After successfully stabilizing the iron powder flame, we conducted experiments combining it with a Stirling engine to test the conversion of the generated thermal energy into electrical energy. The iron oxide powder generated during combustion, along with the hot air, will be separated and collected before being released into the atmosphere, ensuring its recyclability. The collected iron oxide can be reduced back to iron powder using reducing gases such as hydrogen, enabling a complete cycle. Our team's iron combustion system is an innovative technology aimed at reducing carbon emissions by using iron as an alternative fuel. The system utilizes the combustion of iron powder to generate energy and regenerates iron powder from the combustion product, iron oxide, through a reduction reaction, achieving fuel recycling. In terms of creativity, this system not only does not release CO_2 during the energy conversion process but also uses the heat generated from high-temperature combustion to drive a Stirling engine for power generation. Additionally, the iron oxide produced during combustion is solid, making it easy to

	collect and regenerate, avoiding the difficulties of handling exhaust gases in traditional combustion processes. Furthermore, iron is abundant and inexpensive as a fuel source, offering a competitive zero-carbon energy solution for industrial and power generation applications.
Brief of Work (Creativity/Technical content and feasibility)	Our team's iron combustion system is an innovative technology designed to reduce carbon emissions by using iron as an alternative fuel. The system harnesses the energy generated from the combustion of iron powder and regenerates the combustion byproduct, iron oxide, back into iron powder through a reduction reaction, enabling the recycling of the fuel. One of the key innovative aspects of this system is that it does not release CO2 during the energy conversion process. Furthermore, the high-temperature heat generated from combustion can be utilized to drive a Stirling engine for power generation. Additionally, the solid iron oxide produced during combustion is easy to collect and regenerate, avoiding the challenges associated with handling exhaust gases in traditional combustion processes. Iron, as a fuel source, is abundant and inexpensive, offering practical application potential. This provides a competitive zero-carbon energy solution for industrial and power generation sectors.
Expected Benefit	Assuming the successful large-scale replacement of coal by this technology, if Taiwan's annual coal consumption is 50 million tons (50 Mt), replacing 10% of it, i.e., 5 million tons (5 Mt) with the iron combustion system could significantly reduce carbon emissions. The combustion of coal emits approximately 3.67 tons of CO_2 per ton of coal. Therefore, the carbon emissions from burning 5 million tons of coal would be approximately 18.35 million tons of CO_2. Since iron combustion does not release CO_2, every kWh of electricity generated using this system could save 917 g of CO_2. Consequently, replacing coal with the iron combustion system could reduce CO_2 emissions by approximately 18.35 million tons. This demonstrates the potential of the iron combustion system for large-scale carbon reduction and provides a viable solution for future net-zero emissions goals. Currently, our team's technology is still in the laboratory development stage. One of the main future development directions is focusing on steam generation, with an expected thermal efficiency of up to 30%.

編　　號：MAIN 15

作　　品：多元製程開發高效產氫整合一體化系統

學　　校：國立中央大學

系　　所：材料科學與工程研究所

指導教授：王冠文　洪緯璿　李勝偉；(03)4227-151#34906；kuanwen.wang@gmail.com

隊　　長：張家語；0975592132；yu940033@gmail.com

隊　　員：邱玟溢　邱奕嘉　許育逢

項目	內容說明
團隊介紹	本團隊來自中央大學材料所，為達成 2050 年淨零排放的目標，本所專注於創新研發能源材料，而本團隊更聚焦於氫能應用。在本研究成果中，我們提出一套完備的氫能整合運作系統，為高效電解水及海水產氫提供可行且永續的運行方案。
創作動機 (解決問題與技術價值)	氫氣的生產與應用包含觸媒設計、材料科學，電化學與能源工程等領域。本團隊提出了一個完整的電解水(海水)產氫的解決方案，從材料研發到應用技術，包括高熵/中熵觸媒的開發，並探討鈷及其他金屬對觸媒性能的影響，及高熵系統在真實海水中的應用，結合臨場光譜分析技術深入了解反應機制，以優化材料和系統，提供高性能且耐久的觸媒。本技術的重點在於開發能高效利用水(海水)並進行水(海水)分解產氫的觸媒，克服現有產氫觸媒能量轉換效率低、壽命短等問題。
創作過程	我們開發了一套完整的水(海水)電解產氫系統，包含具良好催化活性表現的鈀-鈷金屬產氫(HER)觸媒、高熵/中熵析氧(OER)系統，實現酸性及海水環境電解槽系統高效穩定的氫氣生產。其中，高熵觸媒已實現真實海水產氫，在小電流的條件下穩定運行 1000 小時。 在應用方面，成功整合氫能系統技術(涵蓋:材料/機構/電力電子/韌體演算法/軟體介面)。使用擁有快速反應能力之質子交換膜(PEM)、精密組件結構和多年經驗的電力轉換技術確保穩定電源輸出，整合韌體演算法和人性化界面。本氫能系統為台灣產業界提供商業化最佳範例，完全以 100%氫能，無市電與輔助電池，以升降壓技術(Boost-Buck converter)提供穩定電源給 3C 產品運作。亦提供氫能作為備用電力系統的創新想法，涉及氣體流量控制、感測元件及演算法系統、環境溫度控制以及電壓電流回授資料分析等多項研究成果。
作品介紹 (創意、技術內涵與可行性)	本團隊提出一套完備的氫能整合運作系統。其中，開發鈀-鈷雙金屬觸媒(Pd-Co/NC)，以有機金屬框架衍生物替代碳黑作為支撐物，其特殊的多孔結構經熱解轉化為眾多活性位點，使觸媒同時具有高效能與耐久性。 基於實用化與工業、市場化的考量，同時研究了使用蘊含量豐富且價格較低廉的過渡金屬元素之高熵觸媒系統，發展公斤級量產技術及大面積生產塗佈技術。同時深入探討反應機制、長時間電解之系統和材料失活問題，利用豐沛廉價之海水資源進行大規模的電解製氫以期對台灣的氫能研發和應用做出重要貢獻。
預期效益 (預期的節能效率、產值、數據等具體敘述)	本團隊的研究成果中，我們開發了多種高效的觸媒系統，除了鹼性電解環境產氫外還使用以陰離子交換膜(AEM)技術架構為基礎，新一代具備高性能且低成本之水電解產氫核心及適合在酸性(PEM)下運作的觸媒系統。本技術包含最基礎的觸媒材料設計及後期的組裝與交換膜改質技術。在應用方面，結合綠電電解產氫，無論是儲存與應用都符合如今綠色產業發展與循環經濟的要點，除了在真實海水環境下電催化反應相關領域將帶來極大的貢獻外，雷射製程與後續整合系統也進一步提升氫能於不同領域與產業之應用，為台灣的淨零排放做出重要貢獻。

No. : MAIN 15

Works : Development of a multi-process high-efficiency integrated hydrogen production system

School : National Central University

Dept. : Institute of Material Science & Engineering

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Wei-Hsuan Hung
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Leader : Chia-Yu Chang / 0975592132 / yu940033@gmail.com

Member : Wen-Yi Chiou　Yu-Feng Hs　I-Chia Chiu

ITEM :	DESCRIPTION
Introduction of Team	Our team at the IMSE, NCU focuses on hydrogen energy to achieve net zero emissions by 2050. We have developed an integrated hydrogen production system for efficient (sea) water electrolysis.
Creation Motive (Problem-solving and technical value)	Our team has developed comprehensive (sea) water electrolysis solutions, focusing on catalyst design, materials science, electrochemistry, and energy engineering. We use in situ spectroscopy to explore reaction mechanisms in real seawater and optimize materials and systems, addressing challenges like low energy conversion efficiency and short catalyst lifespan.
Research Process	We use Pd-Co HER catalysts and high/mid-entropy OER catalysts to efficiently and stably produce hydrogen in acidic and seawater environments, with the high-entropy catalyst performing for 1,000 hours in real seawater. Utilizing a rapid-response PEM and advanced power conversion, our system operates entirely on hydrogen energy, providing stable power to 3C products and innovative backup power solutions.
Brief of Work (Creativity/Technical content and feasibility)	We prepared Pd-Co catalysts using metal-organic framework derivatives and high-entropy transition metals to develop kilogram-scale production and large-area coating techniques. We addressed reaction mechanisms and material deactivation issues during long-term electrolysis. By utilizing abundant seawater for large-scale hydrogen production, we aim to advance hydrogen energy research and application in Taiwan.
Expected Benefit	We use anion exchange membrane (AEM), proton exchange membrane (PEM), and high-performance and affordable catalysts for alkaline and acidic environments. We advance electrocatalytic reactions in real seawater and enhance hydrogen energy applications through laser processing and system integration, contributing to Taiwan's net zero emissions goals.

編　　號：MAIN 16
作　　品：自主材料開發之硫化物固態電解質運用於鋰金屬電池
學　　校：國立成功大學
系　　所：材料科學及工程學系
指導教授：鍾昇恆；275-7575 ext.62925；SHChung@gs.ncku.edu.tw
隊　　長：郭昱均；0901-070801；n56115017@gs.ncku.edu.tw
隊　　員：吳承哲　詹子靚　楊世綸　陳奕維

項目	內容說明
團隊介紹	本團隊來自成大材料的電池與儲能科技實驗室，成員由兩位博士生及三位碩士生組成，指導教授為鍾昇恆教授，主要致力於鋰硫電池的材料開發與技術檢測，在提升儲能技術同時達到永續綠能目標。
創作動機 (解決問題與技術價值)	氣候變遷與碳減量議題讓永續再生能源受到重視，礙於其間歇性與隨機性，使非週期性的能源供給提高併入電網的難度。此時，電化學儲能系統可適時供給能源缺口。因此，我們以開發出高能量密度的鋰硫電池為目標，並以固態電解質取代可燃液態電解質提高安全性，用於儲能電網建設。
創作過程	本團隊以高比電容量、高安全性、成本較低與高能量密度的固態鋰硫電池為目標，首先利用高能量一次性球磨法合成硫化物 Li_3PS_4 固態電解質，並利用多硫化物陰極解決鋰硫固態電池所面臨的介面問題，成功開發出具有優秀性能與循環穩定性的鋰硫電池。
作品介紹 (創意、技術內涵與可行性)	本團隊利用高能量一次性球磨法合成硫化物 Li_3PS_4 固態電解質此法合成出來的硫化物固態電解質為非晶質結構,相比於文獻普遍利用需要不斷開罐與高溫燒結的合成法，此法更具有批量合成的潛力，固態電解質的使用也提升了電池的安全性。但由於固態電解質的固態介面接觸是一大阻礙,因此本團隊利用液態多硫化物配合集流體作為陰極，高濃度的多硫化物使用可以達成高硫載量，並在前期組裝電池時將介面問題加以改善，使電池循環穩定的同時克服了界面問題，並且無需在高壓力下進行電池之充放電。
預期效益 (預期的節能效率、產值、數據等具體敘述)	首先本團隊利用了多硫化物作為陰極，並以此得到高活性物質載量 (3–6 mg cm^{-2})，而固態電解質的使用可以避免高活性鋰與有機電解液的副反應，從而有效抑制鋰枝晶生長並穿透隔離膜，提高安全性的同時也促進了電池的庫倫效率。實驗合成之固態電解質在不同厚度下的電池循環性能皆在 800 mAh g^{-1} 以上，其中最高者更可以達到 1450 mAh g^{-1}，相較目前商用鋰離子電池之電容量高了 4-7 倍，且達到了實際的高面積容量和高能量密度，(6.8–11.3 mWh cm^{-2}) 與長循環穩定性 (>100 cycles)，高於目前固態電池研究之平均值。此作品之技術擁有高安全性及高能量密度，性能優於目前市面上開發之電池，期許與業界攜手共築儲能以達到永續台灣的願景。

No. : MAIN 16

Works : Self-development of Sulfide Solid-state Electrolytes for Lithium Metal Batteries

School : NCKU

Dept. : Material Science and Engineering

Advisor : Sheng-Heng Chung / 275-7575 ext.62925 / SHChung@gs.ncku.edu.tw

Leader : Yee Jun Quay / 0901-070801 / n56115017@gs.ncku.edu.tw

Member : Cheng-Che Wu Tzu-Ching, Chan Shih-Lun, Yang Yi-Wei Chen

ITEM :	DESCRIPTION
Introduction of Team	Our team is from the Battery-Energy Storage Technology lab at the Department of Materials Science and Engineering, National Cheng Kung University. The team consists of two PhD students and three master students under the supervision of Professor Sheng-Heng Chung. We are dedicated to the development of materials and technology for lithium–sulfur batteries, aiming to enhance energy storage technology while achieving the goals of sustainable green energy.
Creation Motive (Problem-solving and technical value)	Climate change and carbon reduction issues have brought sustainable renewable energy into focus. However, the intermittency and randomness of the renewable energy make it difficult to integrate non-periodic energy supply into the grid. At this time, energy storage systems can timely supply the energy gap. Therefore, our goal is to develop high-energy-density lithium–sulfur batteries and replace flammable liquid electrolytes with solid-state electrolytes to improve safety, which can be further applied in energy storage grid construction.
Research Process	Our team aims to develop solid-state lithium–sulfur batteries with high safety, low cost, and high energy density. Initially, we synthesized the Li3PS4 sulfide solid-state electrolyte using a high-energy ball milling and used a polysulfide cathode to solve the interface problems. We successfully developed lithium–sulfur batteries with excellent performance and cycle stability.
Brief of Work (Creativity/Technical content and feasibility)	The high-energy ball milling is used to synthesize the sulfide Li3PS4 solid-state electrolyte with an amorphous structure. Compared to the commonly used methods in the literatures, which require continuous opening and high-temperature sintering, our method has high potential for mass synthesis and production. The use of solid-state electrolytes also improves battery safety. However, the interface contact of solid-state electrolytes is a major obstacle. Therefore, our team uses liquid

	polysulfides combined with current collectors as the cathode. The use of high-concentration polysulfides can achieve high sulfur loading while improving interface issues during the initial assembly of the battery, ensuring cycle stability and overcoming interface problems without the need of high-pressure during battery charging and discharging.
Expected Benefit	First, our team used polysulfides as the cathode, achieving a high active material loading (3–6 mg cm–2). The use of solid-state electrolytes can avoid side reactions between highly active lithium and organic liquid electrolytes, effectively inhibiting lithium-dendrite growth and penetration through the separator, thereby improving safety and promoting the Coulombic efficiency of the battery. The cycle performance of the lithium–sulfur batteries with synthesized solid-state electrolyte can achieve capacity above 800 mAh g–1, with the highest reaching 1450 mAh g–1, which is 4–7 times higher than the current commercial lithium-ion battery capacity. Additionally, it achieves practical high areal capacity and high energy density (6.8–11.3 mWh cm–2) with long cycle stability (> 100 cycles), higher than the average values of current solid-state battery research. The technology of this work possesses high safety and high energy density, with performance superior to currently developed batteries in the market. We hope to work hand to hand with the industry to build energy storage systems and achieve the vision of a sustainable Taiwan.

編　　號：MAIN 17
作　　品：電驅動酸鹼震盪碳捕捉再利用
學　　校：國立臺灣大學
系　　所：生物環境系統工程學系
指導教授：潘述元；0921839147；sypan@ntu.edu.tw
隊　　長：林育誼；0911875620；09622013@ntu.edu.tw
隊　　員：曾渤之　鄭又綺　陳心儀　葉晉豪

項目	內容說明
團隊介紹	本團隊來自於國立臺灣大學生物環境系統工程學系潘述元教授帶領指導的綠色科技實驗室，團隊主要研究電驅動技術用於廢水、資源循環再利用，此次將電驅動技術用於碳捕捉，研究成果可有效兼具碳捕捉效益，且輸出之各項能資源可回饋至能源及生態系統進行妥善利用，為一項相當具有發展潛力之技術。
創作動機 (解決問題與技術價值)	為了創造負碳效益，國際間積極開發測試重要「負碳」技術（又稱負排放技術或碳移除技術），以抵銷製造程序溫室氣體排放，實現淨零（Net-Zero）願景。本作品以目前觀察到亟待解決的議題與 CO_2 捕捉技術研究的發展趨勢，開發電驅動酸鹼震盪碳捕捉再利用技術，除可捕捉 CO_2 更可提升沼氣純度價值，亦結合再生能源或者離峰用電，將電能轉換為天然氣回饋於天然氣網。
創作過程	本作品利用電驅動酸鹼震盪產生氫氧根離子，針對厭氧發酵後之沼氣中二氧化碳快速反應進行捕捉，並藉此提升沼氣中甲烷濃度，純化後之沼氣可回饋於天然氣網使用，同時減少沼氣排放至大氣，捕捉二氧化碳產生之碳酸鹽類產品，可做為其他工業產品或者提供給藻類作為輔碳加速其生長及增加生質產量，達到固碳或者後續製造生物碳、生質酒精等高價值產品，可視作為結合淨零排放及符合經濟價值發展的關鍵技術選項之一。
作品介紹 (創意、技術內涵與可行性)	本作品透過電化學酸鹼震盪之綠色工程技術，並應用於沼氣中 CO_2 捕捉以實現沼氣純化之目標。電化學碳捕獲相較傳統技術具有高能源效率、可常溫常壓下操作、 避免化學品使用與廢物生成等優點,符合綠色化學原則,且在從空氣、海水等低濃度溶液中捕捉二氧化碳方面具有顯著潛力與優勢,可直接將捕獲之二氧化碳轉換成含碳酸鹽產品,實現二氧化碳再利用。而本團隊過去已有相當多成功經驗,利用電化學系統回收廢棄物中有價資源,實現循環經濟。 電驅動酸鹼震盪模組由電極、離子交換膜和離子交換樹脂以交錯夾層方式排列組成,透過通以直流電,將通入系統之水溶液解離成氫離子與氫氧根離子,促使系統中形成 pH 值大於七和小於七之兩種酸鹼環境。根據熱力學原理, 以 pH 值震盪來控制水中溶解的無機碳(DIC)濃度,因此氣流中 CO2 可於鹼性室中被捕獲 / 吸收,隨後在酸性室中釋放或回收再利用。 本研究結果顯示於電驅動酸鹼震盪的操作條件下，從連續式進氣之混合氣體(40% CO2)中去除約為 50%之 CO2,操作 30 分鐘後於 2 公升溶液中累積可吸收 7.5 g-CO2，並形成約 0.02 M 碳酸氫鈉溶液。比較未通電操作條件,施壓電壓可提升二氧化碳吸附效率,且 CO2 吸收量提升約 3 倍,可見利用電解作用產鹼,可成功持續提供氫氧根離子 OH-，來吸收更多 CO2。 此技術應用層面廣泛，除本作品試驗標的，針對厭氧發酵後之沼氣中二氧化碳快速反應進行捕捉，並藉此提升沼氣中甲烷濃度，純化後之沼氣可回饋於天然氣網使用，同時減少沼氣排放至大氣，亦可用於直接空氣捕捉（DAC）或燃燒後二氧化碳捕捉等途徑；同時，二氧化碳將轉換成含碳酸鹽類產品，不需再經由催化轉換成其他產品，可直接實現一步直接二氧化碳捕捉再利用，而純化後之沼氣可直接回饋於天然氣網使用，達成三贏的目的（減少溫室氣體排放、沼氣純化、碳酸鹽類產品）。
預期效益 （預期的節能效率、產值、數據等具體敘述）	本技術目前以實驗室規模 $0.78m^2$ 離子交換膜膜截面積，沼氣(40%CO2)負荷量為 $0.74m^3/m^2/d$，可產生約 85% CH_4 純化沼氣 $0.46m^3/m^2/d$，獲得 $360L/m^2/d$-1.5g/L 碳酸鹽類產品，補碳效益為 38.5 kg-$CO_2/m^2/d$；未來透過模組規模放大化其處理之氣量可提升至約 50 倍，除可以捕捉二氧化碳、純化沼氣回饋於氣網，碳酸氫根水溶液可作為生質藻類之碳源或其他工業產品用途，同時電驅動可直接由光電能(DC)直接驅動，更具有儲能之效益，能做為未來能源發展關鍵技術選項之一。

No. : MAIN 17

Works : Electro-driven pH Swing Carbon Capture and Utilization

School : National Taiwan University

Dept. : Department of Bioenviromental System Engineering

Advisor : Shu-Yuan Pan / 0921839147 / sypan@ntu.edu.tw

Leader : Yu-I Lin / 0911875620 / f09622013@ntu.edu.tw

Member : Po-Chih Tseng Yu-Chi Cheng Hsin-Yi Chen Chin-Hao Yeh

ITEM	DESCRIPTION
Introduction of Team	We are Green Technology Lab led by Professor Pan Shu-Yuan from the Department of Bioenvironmental Systems Engineering at National Taiwan University. We focus on the GREAT (Green Research for Environmental and Agricultural Technologies) to realize BCG (Bio-Circular-Green) economy system. Our group specializes in the development of electrokinetic separation technology and practical applications of of water reuse and waste conversion technologies, especially in electrochemical systems. We have our own laboratory focusing on separation systems for agricultural and environmental applications towards a circular economy. In some cases, we also collaborate with experimental groups around the world.
Creation Motive (Problem-solving and technical value)	To create negative carbon benefits, international efforts are actively developing and testing key "Carbon Negative" technologies (also known as negative emissions technologies or carbon removal technologies) to offset greenhouse gas emissions from manufacturing processes and achieve the Net-Zero vision. This work, in response to urgent issues observed and the development trends in CO_2 capture technology, has developed an electro-driven pH Swing carbon capture and utilization technology. This technology can upgrade natural gas using renewable energy or off-peak electricity, which can be fed back into the natural gas grid to improve the resource efficiency.
Research Process	This work utilizes electro-driven water splitting to generate hydroxide ions for rapid reaction and capture of gaseous carbon dioxide (such as CO_2 in air, flue gas, or biogas). The research process and objectives include: (1) Developing a green electro-driven pH Swing CO_2 capture technology; (2) Evaluating the treatment efficiency and energy consumption of the electrochemical CO_2 capture process; and (3) Assessing the

	performance differences when expanding the application of the technology, such as for direct air capture or biogas purification processes. Additionally, the carbonate products generated from CO_2 capture can be used in other industrial applications or provided as a supplemental carbon source for algae cultivation, accelerating their growth and increasing biomass yield. This approach not only facilitates carbon sequestration but also supports the production of high-value products such as biochar and bioethanol. As such, it represents a key technological option that aligns with Net-Zero emissions goals while offering economic benefits.
Brief of Work (Creativity/Technical content and feasibility)	This work employs green engineering technology based on electrochemical pH-Swing and applies it to capture CO_2 from biogas to achieve biogas purification. Compared to traditional technologies, electrochemical carbon capture offers high energy efficiency, can be operated at ambient temperature and pressure, and avoids the use of chemicals and waste generation. This approach aligns with the principles of green chemistry and has significant potential and advantages in capturing carbon dioxide from low-concentration solutions such as air and seawater. The captured CO_2 can be directly converted into carbonate-containing products, achieving carbon dioxide reuse. Our team has substantial experience in using electrochemical systems to recover valuable resources from waste, realizing a circular economy. The electro-driven pH-swing module is composed of electrodes, ion exchange membranes, and ion exchange resins arranged in an interleaved manner. By applying direct current, the water solution passing through the system dissociates into hydrogen ions and hydroxide ions, creating two different pH environments in the system: one with a pH greater than seven and one with a pH less than seven. According to thermodynamic principles, controlling the concentration of dissolved inorganic carbon (DIC) in water through pH-swing allows CO_2 in the airflow to be captured/absorbed in the alkaline chamber and then released or recycled in the acidic chamber. The study results show that under the operating scenario of electro-driven pH-swing, about 50% of CO_2 can be removed from a continuous feed of mixed gas (40% CO_2). After 30 minutes of operation, 7.5 g-CO_2 can be

	absorbed in 2 liters of solution, forming approximately 0.02 M sodium bicarbonate solution. Compared to the non-electrified operation scenario, applying voltage increases CO_2 adsorption efficiency, with CO_2 absorption increased by about three times. This indicates that the electrolysis process generates alkalinity and continuously provides hydroxide ions (OH^-) to absorb more CO_2. This technology has broad applications beyond the tested scope of this work. It can quickly capture CO_2 from biogas after anaerobic fermentation, increasing the methane concentration in the biogas. The purified biogas can be returned to the natural gas network, reducing biogas emissions into the atmosphere. It can also be used for direct air capture (DAC) or post-combustion CO_2 capture. Additionally, CO_2 is converted into carbonate-containing products directly without further catalytic conversion, allowing for one-step CO_2 capture and reuse. The purified biogas can be directly returned to the natural gas network, achieving a triple win: reducing greenhouse gas emissions, purifying biogas, and producing carbonate products.
Expected Benefit	Currently, this technology operates at a laboratory scale with an ion exchange membrane cross-sectional area of 0.78 m^2. The feed load (containing 40% CO_2) is 0.74 m^3/m^2/day, resulting in the production of approximately 0.46 m^3/m^2/day of purified biogas with 85% methane (CH_4) concentration. Additionally, it generates 360 L/m^2/day of carbonate products with a concentration of 1.5 g/L, achieving a carbon sequestration efficiency of 38.5 kg-CO_2/m^2/day. In the future, scaling up the modular system could increase the processing capacity by approximately 50 times. Besides CO_2 capture, purified biogas could be fed back into the gas grid, and produce bicarbonate solutions that could serve as a carbon source for biomass algae or other industrial applications. Furthermore, the electro-driven process can be directly powered by renewable energy, offering energy storage benefits. This positions the technology as a critical option for future energy development.

編　　號：MAIN 18

作　　品：奈米纖維素混摻鈣鈦礦形成新穎奈米纖維膜以提升光學性質及熱穩定性

學　　校：國立臺北科技大學

系　　所：分子科學與工程

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隊　　長：徐紫軒；0900017997；mjyfklrw3963@gmail.com

隊　　員：吳靖揚　林鎧薇

項目	內容說明
團隊介紹	本團隊來自「前瞻高分子材料及奈米科 技實驗室」團隊主要研究自修復高分子、靜電紡絲 、LED、發光材料-鈣鈦礦並朝向綠色材料或是材料的方向發展。
創作動機 (解決問題與技術價值)	因為近年來石油危機，生質材料受到了大家的重視，生質材料取代部分石油產品，是目前未來的趨勢。生質材料在數量上沒有匱乏的問題、減少碳足跡以及丟棄時對環境的負擔較小，且因為生質材料通常都具有的優秀物理特性，例如低密度高強度比表面積大及不易熱變形的穩定性，讓生質材料亦可以應用在高強度材料製備或是多功能材料的製備。我們將結合發光材料-鈣鈦礦，並利用生質配體或是生質高分子幫助修復晶體缺陷以及提升光學性質，並利用靜電紡絲技術製備出奈米纖維。
創作過程	1.PMMA (Poly (methyl methacrylate))纖維膜製作:首先取 CNC (Cellulose Nanocrystals)配製成 CNC 溶液，再配置鈣鈦礦前驅液。隨後將兩種溶劑混合並加入 PMMA。即可進行靜電紡絲。 2.CA (Cellulose acetate)纖維膜製作:首先配置鈣鈦礦前驅液以及 CA 前驅液，隨後將兩種溶劑混合即可進行靜電紡絲。
作品介紹 (創意、技術內涵 與可行性)	我們開發結合鈣鈦礦和生質材料，並使用靜電紡絲的技術，製成新穎奈米纖維膜，應用於白光 LED。 1.鈣鈦礦材料介紹:鈣鈦礦本身具有優良光學性質，但在大氣中容易降解並釋放具有毒性離子與配體(如:鉛離子、OA、OAm)，因此我們透過結合生質材料(如生質小分子與高分子)以及靜電紡絲技術，解決鈣鈦礦的問題。 2.生質材料:生質材料易取得且價格便宜、減少碳足跡及降低鈣鈦礦毒性。 a.配體置換生質材料 CNC (Cellulose Nanocrystals)：我們使用具有硫酸根官能基的 CNC，並提升光學性質及大氣中穩定性。並利用靜電紡絲進行 CNC 的配體封裝，且證明 CNC 可以取代原先的配體具有更好的光學性質和熱穩定性，進一步減少降解與有毒離子外洩。 b.高分子置換生質材料 CA (Cellulose acetate)：我們使用具有多種官能基的醋酸纖維素進一步取代非生質高分子，CA 高分子除了可以保持鈣鈦礦其原有良好光學性質外，亦能減少製程碳排放與增加產品生物佔比。
預期效益 （預期的節能效率、產值、數據等具體敘述）	1.提高環境穩定性:鈣鈦礦材料 $CsPbBr_3$ 具備優異的光電特性，然而，鈣鈦礦材料在應用中易受環境因素影響，使用靜電紡絲的技術進行封裝，能夠有效包覆並保護鈣鈦礦。 2.改善材料穩定性和機械性能:使用奈米纖維素具有優異的機械強度、熱穩定性與豐富官能基，當其作為包覆材料時，可以顯著提高奈米纖維膜的整體性能。而使用生質高分子 CA 可以降低製程碳排並增加產品生物佔比。 3.節省能源的製造過程:奈米纖維素的提取和處理相對簡單且環保，不需要高能耗的製造過程。符合綠色製造的理念，還減少了能源消耗和環境污染。 4.纖維多功能可撓式元件應用和能源效率提升

No. : MAIN 18

Works : Nanocellulose mixed with perovskite forms a novel nanofiber membrane to improve optical properties and thermal stability

School : National Taipei University of Technology

Dept. : Department of Molecular Science and Engineering

Advisor : 郭霽慶 / 02-2771-2171 #2407 / kuocc@mail.ntut.edu.tw

Leader : 徐紫軒 / 0900017997 / mjyfklrw3963@gmail.com

Member : 吳靖揚 林鎧薇

ITEM	DESCRIPTION
Introduction of Team	This team from the Advanced Polymer and Nanotechnology Laboratory primarily focuses on research in self-healing polymers, electrospinning, LEDs, and luminescent materials, specifically perovskites. Their work is oriented towards the development of green materials and sustainable technologies.
Creation Motive (Problem-solving and technical value)	In recent years, the oil crisis has brought increasing attention to biomass materials. These materials are seen as a promising alternative to petroleum products, reflecting a broader trend towards sustainable and renewable resources. Biomass materials are abundant, reduce the carbon footprint, and are environmentally friendly when discarded. They possess excellent physical properties such as low density, high strength, a large specific surface area, and resistance to thermal deformation. These characteristics make biomass materials ideal for developing high-strength or multifunctional materials. Our research focuses on combining the luminescent material perovskite with biomass ligands or biopolymers. This combination aims to repair crystal defects and enhance optical properties. Additionally, we employ electrospinning technology to prepare nanofibers, integrating these advanced materials into a novel format that leverages the strengths of both perovskites and biomass components.
Research Process	PMMA (Poly (methyl methacrylate)) Fiber Membrane Production

	CA (Cellulose acetate) Fiber Membrane Production
Brief of Work (Creativity/Technical content and feasibility)	We develop novel nanofiber films that combine perovskite and biomass materials using electrospinning technology for white light LED applications. 1. Introduction to Perovskite Materials: Perovskite materials possess excellent optical properties; however, they are prone to degradation in the atmosphere and contain toxic ions (such as lead ions, OA, and OAm). To address these issues, we incorporate biomass materials (such as replacement ligands or polymers) and employ electrospinning technology. 2. Introduction to Biomass Materials: Biomass materials are readily available and cost-effective and help reduce the carbon footprint and the toxicity of perovskite. a. Ligand Replacement Biomaterial CNC (Cellulose Nanocrystals): We utilize CNC with sulfate functional groups to enhance optical properties and atmospheric stability. Electrospinning is employed to encapsulate CNC ligands, demonstrating that CNC can effectively replace the original ligands, offering improved optical properties and thermal stability. b. Polymer Replacement Biomaterial CA (Cellulose acetate): CA, which contains various functional groups, is used to reduce perovskite toxicity and increase the bio-content.
Expected Benefit	Improve environmental stability、Improve material stability and mechanical properties、Energy-saving manufacturing process、Multifunctional applications and energy efficiency improvements

編　　號：MAIN 19

作　　品：開發全水解可回收生物性黏結劑及電解質在鋰電池的應用

學　　校：國立清華大學

系　　所：工程與系統科學系

指導教授：吳孟真；0932152960；philwu@gmail.com

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隊　　長：陳彥睿；0937912216；must2600@gapp.nthu.edu.tw

隊　　員：蘇毓軒　鐘晉毅　陳偉銘

項目	內容說明
團隊介紹	我們的團隊來自中央研究院物理研究所，由清大工科系的學生與中興大學吳孟真教授以及中原大學紀柏葦教授共同聚集的研究室，致力於鋰電池的相關開發與降低電池衝擊環境的研究。
創作動機 (解決問題與技術價值)	目前的電池技術面臨環境污染和健康風險，尤其是由有毒黏合劑和液態電解液引發的問題。傳統的聚偏氟乙烯(PVDF)黏合劑中的溶劑 N-甲基-2-吡咯烷酮(NMP)對環境和健康有害。我們的團隊使用天然多糖聚合物果膠(Pectin)和聚乙二醇(PEG)混合凝膠作為黏結劑，取代了 PVDF，並以此開發新型凝膠聚合物電解質(GPE)，以提高電池的安全性。本研究旨在探索環保、可再生的果膠基黏合劑和新型凝膠電池材料，解決當前電池技術中的毒性和安全問題。
創作過程	在現有鋰電池離子回收工藝中的一個關鍵問題是，使用 PVDF 作為電極粘合劑的鋰離子電池在煅燒處理時會排放有害氣體和不需要的化合物。迫切需要環保的粘合劑來取代 PVDF。多糖聚合物如藻酸鹽和羧甲基纖維素是潛在的替代材料，其中果膠因其可生物降解和無毒性，成為本研究的重點。在鋰金屬電池的充放電過程中，傳統液體電解質難以抑制鋰枝晶的形成。而固態聚合物電解質因為具有優異的電化學穩定性和良好的機械強度，已被證明是液體電解質的有效替代品，能抑制鋰枝晶的生長，提高電池的安全性。 ● 可回收生物性黏結劑與電解質技術 ● 已完成實驗室規模鈕扣量測系統建置與測試 ● 具備全電池規格與產品外觀設計經驗

作品介紹 (創意、技術內涵與可行性)	本團隊開發水系材料生物質果膠(Pectin) 和聚乙二醇(PEG) 開發黏結劑，成功將負極材料石墨、釩酸鋰以及正極材料磷酸鐵鋰塗佈在集電體上(Al、Cu foil) ，並且分別在 1C 功率充放電效率中經過 500 圈電容量保持率還達到 99 %，且在 3C 功率下經過 500 圈也能保持 97 % 以上電容量保持率。由於是一種環保且可水溶性的材料，所以對於循環後的回收也相對容易，經回收測試後可以達到 95 % 左右的材料回收率。 本團隊也在設計開發一種同樣以果膠與乙二醇結合的水溶性的準固態電解質(Quasi-Solid Electrolyte)，在設計成膜比例上，以果膠比乙二醇 1 : 3 的比例下達成最高離子導電度的膜並命名為 PP275，在測試不同濃度的硝酸鋰($LiNO_3$) 為電解質中提供鋰離子的鋰鹽的實驗中，以 0.25M 為最佳添加比，也成功完成在 0.1C 功率充放電 100 圈保持 99 % 的電容量保持率， 在高功率 1C/3C 的情況下也能在循環 270 圈後保持 79%電容量保持率。 我們結合開發的水系果膠 / 聚乙二醇黏結劑所塗佈的極片和電解質，組成電池並測試。由於不須添加液態電解質，且硬度較高不易形成鋰枝晶(dendrite)，有望直接開發鋰金屬電池，推高能量密度。 最後本團隊測試回收能力，因為所使用的材料均可以輕易地被水所溶解，這在回收中有很大的幫助，只需要簡易的將電池包拆開溶水、洗淨、分離、加熱提純即可得到有價的活性材料以及溶在水中的鋰鹽。
預期效益 （預期的節能效率、產值、數據等具體敘述）	● 鋰電池中的黏著劑雖成本占比小，但扮演重要角色。市場上主要使用聚偏二氟乙烯(PVDF)作為黏著劑，年需市場需求量約 10~20 萬噸，年產值約 5~10 億。果膠的導入預期將有效減少 20%的碳排放。 ● 鋰電池中的電解液多為碳基有機溶劑，2024 年預估需求量約 1500 萬噸。未來將果膠應用於電解液和黏結劑，可降低現有電解液生產所排放的 CO2 31~50%，總碳排放量將減少 750 萬噸，相當於 19405 座大安森林公園的年吸碳量。這將使台灣在減碳趨勢中大幅領先。

No. : MAIN 19

Works : Developing Hydrolyzable and Recyclable Bio-based Binders and Electrolytes for Applications in Lithium Batteries

School : National Tsing Hua University

Dept. : Department of Engineering and System Science

Advisor : Phillip M. Wu / 0932152960 / philwu@gmail.com

Po-Wei Chi / 0937546969 / dr.pwchi@gmail.com

Leader : Yan-Ruei Chen / 093791216

Member : Yu-Hsuan Su Chin-Yi Chung Wei-Ming Chen

ITEM :	DESCRIPTION :
Introduction of Team	Our team is from the Institute of Physics at Academia Sinica, comprised of students from the Department of Engineering at National Tsing Hua University, and collaborating with Professor Phillip M. Wu from National Chung Hsing University and Professor Po-Wei Chi from Chung Yuan Christian University. We are dedicated to the development of lithium batteries and research aimed at reducing the environmental impact of batteries.
Creation Motive (Problem-solving and technical value)	The purpose of this research is to explore and develop renewable and environmentally friendly pectin-based aqueous binders and novel electrolyte materials to address the toxicity, safety, and recycling challenges currently faced by battery technology. Current batteries pose environmental pollution and safety issues. Commercially, polyvinylidene fluoride (PVDF) and N-methyl-2-pyrrolidone (NMP) are widely used, both of which have biological toxicity, posing threats to the environment and health. To solve these problems, our team uses a mixture of polysaccharide polymer—pectin (Pectin) and polyethylene glycol (PEG)—as a binder to effectively replace PVDF. Using this gel, we develop novel gel polymer electrolytes (GPE) to enhance battery safety and ensure that the materials can be easily recycled through hydrolysis.
Research Process	One critical issue in current lithium-ion battery recycling processes is that lithium-ion batteries using PVDF as an electrode binder emit harmful gases and undesirable compounds during calcination. There is an urgent need for environmentally friendly binders to replace PVDF. Polysaccharide polymers such as alginate and carboxymethyl cellulose are potential alternatives, with pectin being the focus of this study due to its biodegradability and non-toxicity. During the charge and discharge processes of lithium metal batteries, traditional liquid electrolytes struggle to suppress the formation of lithium dendrites. Solid polymer electrolytes, with their excellent electrochemical stability and good mechanical strength, have proven to be effective substitutes for liquid electrolytes, capable of inhibiting lithium dendrite growth and improving battery safety. • Recyclable Bio-based Binder and Electrolyte Technology • Established and tested a laboratory-scale coin cell measurement

	system • Experienced in full battery specifications and product appearance design
Brief of Work (Creativity/Technical content and feasibility)	Our team has developed aqueous biomass materials using Pectin and PEG as binders. We successfully coated anode materials such as graphite and lithium vanadium oxide, and cathode material lithium iron phosphate on current collectors (Al, Cu foil). These materials exhibited a 99% capacity retention after 500 cycles at a 1C rate and maintained over 97% capacity retention after 500 cycles at a 3C rate. Due to their environmentally friendly and water-soluble nature, recycling these materials is relatively easy, achieving approximately 95% material recovery after testing. Our team is also designing and developing a quasi-solid electrolyte (QSE) combining pectin and PEG. By optimizing the film composition with a pectin-to-PEG ratio of 1:3, we achieved the highest ionic conductivity and named this film PP275. In experiments with different concentrations of lithium nitrate (LiNO3) as the lithium salt electrolyte, 0.25M was found to be the optimal addition. This electrolyte successfully maintained 99% capacity retention after 100 cycles at a 0.1C rate, and at high power (1C/3C), it retained 79% capacity after 270 cycles. We combined the developed aqueous pectin/PEG binders with electrolytes to assemble and test batteries. Without the need for liquid electrolytes and with higher hardness preventing the formation of lithium dendrites, this approach shows promise for directly developing lithium metal batteries with higher energy density. Finally, we tested the recycling capability of our materials. Since all materials used can be easily dissolved in water, the recycling process is significantly simplified. By simply disassembling the battery pack, dissolving in water, washing, separating, and heating for purification, we can recover valuable active materials and lithium salts dissolved in water.
Expected Benefit	While the cost proportion of adhesives in lithium batteries is small, they play a crucial role. Currently, the market predominantly uses PVDF as a binder, with an annual market demand of approximately 100,000 to 200,000 tons and an annual output value of around 500 million to 1 billion dollars. The introduction of pectin is expected to effectively reduce carbon emissions by 20%. Lithium battery electrolytes are mostly carbon-based organic solvents, with an estimated demand of about 15 million tons in 2024. In the future, the application of pectin in electrolytes and binders could reduce CO2 emissions from the production of existing electrolytes by 31-50%, resulting in a total reduction of 7.5 million tons of carbon emissions. This is equivalent to the annual carbon absorption of 19,405 Taipei-Da’an Forest Parks. This advancement will significantly position Taiwan at the forefront of the carbon reduction trend.

編　　號：MAIN 20

作　　品： 資能協同於去化污泥之綠色隔熱材與綠智雙軸永續應用

學　　校： 國立台北科技大學

系　　所： 土木工程系、能源與冷凍空調工程系、電機工程系

指導教授： 陳立憲　陳清祺；0955803558；0989127549

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隊　　長： 郭彥廷；0975719987；t111428028@ntut.org.tw

隊　　員： 康宇翔　賴建豪　曾子軒　葉昀昇

項目	內容說明
團隊介紹	本團隊是由土木、能源及電機三系所組成的三合一團隊，開發將有機、無機之泥質廢棄物循環利用之大地聚合材，以實現經濟循環再利用，除此之外，為使大量去化及擴大使用由行擴散至住，配合能源系之估使用 CFD 模擬估算其節能效益與電機系之智化物聯網量測，使本團隊可達到資源與能源的有效利用之資能協同、與智化物聯網之能源/設備監測達成綠智雙軸轉型之雙目標。
創作動機 (解決問題與技術價值)	建築業和營建業產生的年碳排放量占全球總排放量的 38%，其中 26%來自建材和營造階段。水泥作為建材中使用量最大的物料，其碳排放量占全球總排放量的 7%，由於其產業製程特性，造成了嚴重的碳排放問題。因此，本研究旨在通過創新使用泥質廢棄物製作隔熱材，發展綠色材料的開發與在建築上的應用，並結合 AIoT 達到智慧健康建築的目標，實現營建行業的可持續發展和建築減碳。
創作過程	我們將泥質廢棄物（如污水廠污泥、淨水廠淤泥等）通過電滲透法降低含水量製成大地聚合材（Geopolymer），並根據不同的粉灰泥和液固比製成多種試體，以達到隔熱、降噪、減振的最佳配比。使用 CFD 模擬軟體進行環境參數預建模和分段模擬，優化隔熱效果，進行施工前能源估算。施工後，建置智化物聯網（AIoT）系統，自動化量測並驗證隔熱效果，結合公有雲數據進行精確的節能效益分析，實現資源和能源協同目標。
作品介紹 (創意、技術內涵與可行性)	本計畫創新地使用經電滲透脫水的無水泥/含污泥之大地聚合材，通過發泡控制使其具備消能、防火、隔熱、減振、降噪等特性。材料已試用於明隧道防落石，現試驗於社會住宅屋頂隔熱，並期望未來擴大至住宅隔間隔熱、減振、降噪。通過 CFD 電腦模擬和智化物聯網（AIoT）系統進行實際量測，驗證其效果。
預期效益 （預期的節能效率、產值、數據等具體敘述）	從材料製作、實驗數據分析到軟體計算，我們將創新材料應用於台北錦州街公宅進行概念驗證。透過案場架設來對照舊有隔熱材之隔熱效果優劣，改善普通隔熱材隔熱效果。這項技術創新將創意轉化為實際應用，並在環境保護和能源節約上做出了貢獻，透過與數個合作案驗證材料的效果，將此例成為典範並擴散至其他社會住宅，期望未來實現可持續發展的創業實踐。

No. : MAIN 20

Works : Synergistic Resource and Energy Utilization for Sustainable Application of Green Intelligence in Pollution Remediation and Building Insulation Materials

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ITEM :	DESCRIPTION
Introduction of Team	This multidisciplinary team, including experts in Civil, Energy, Refrigeration, Air-Conditioning, and Electrical Engineering, develops geopolymer materials from sludge waste for economically viable recycling. They focus on large-scale decontamination and expanding material use from industrial to residential areas. Utilizing CFD simulations and intelligent IoT for motor systems, they estimate energy savings, optimize resource use, and advance green-smart technology through enhanced monitoring.
Creation Motive (Problem-solving and technical value)	The construction industry accounts for 38% of global carbon emissions, with 26% from building materials and construction. Cement alone contributes 7% of these emissions. This research seeks to mitigate these issues by developing green construction materials from sludge waste for insulation. Integrating these materials with AIoT technology aims to create smart, healthy buildings, support sustainable construction, and reduce carbon emissions.
Research Process	This research uses electroosmosis to dewater sludge from sewage and water treatment plants, creating geopolymer materials. Various formulations are tested to optimize thermal insulation, noise reduction, and vibration dampening. CFD simulations model performance and estimate energy savings. After construction, an AIoT system verifies insulation effectiveness, with data analysis ensuring efficient resource and energy use.
Brief of Work (Creativity/Technical content and feasibility)	This project uses electroosmosis-dehydrated sludge to create geopolymer materials with energy dissipation, fire prevention, thermal insulation, vibration reduction, and noise reduction properties. The innovated Geopolymer is made from industrial wastes (sludge+slag) with no cement added. Tested for rockfall prevention in tunnels and currently evaluated for roof insulation in social housing, future uses are expected to include residential partition insulation. The materials' effectiveness is verified through CFD simulations and an AIoT system.
Expected Benefit	Innovative materials were tested at Jinzhou Street Public House in Taipei, showing improved insulation, environmental benefits, and energy savings. Sludge volume was reduced by 50%, with a projected 50% energy saving in insulation. The model has been adopted in other social housing projects, aiming for future sustainable practices.

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