

出國報告（出國類別：其他-參加國際會議）

參加 Healthy Buildings 2023 健康建築研討會暨
拜會德國建材逸散實驗室設施暨研究機構進
行技術交流報告書

服務機關：內政部建築研究所

姓名職稱：姚志廷聘用研究員

派赴國家：德國

出國期間：112年6月9日至6月15日

報告日期：112年9月7日

摘要

近年來，全球都面臨了地球暖化及COVID-19疫情的雙重夾擊，節能建築及健康建築已成為世界各國最重視的建築議題之一，在此背景下，國際間對於相關領域的研究和推動工作，在後疫情時代更為蓬勃發展。為瞭解全球健康建築領域發展現況及未來趨勢，本所派員參加112年6月11日至14日於德國亞琛(Aachen)舉辦之Healthy Buildings 2023健康建築研討會並拜會亞琛工業大學建築系及能源研究中心。

本國際研討會是亞琛工業大學和亞琛工業大學附設醫院在國際室內空氣品質和氣候協會(International Society of Indoor Air Quality and Climate, ISIAQ)的贊助下共同舉辦，本次會議有來自全球38個國家的專業人士與會。本報告內容包括出國目的、會議介紹、主辦單位介紹、會議過程等，亦針對與本所業務較為相關之議題進行說明，包括：需量反應應用於建築節能、室內乙醛健康風險議題、建築外殼節能、建材逸散檢測之環控箱尺寸等議題，最後，本報告提出相關參與心得及建議，期能作為本所推動綠建築、綠建材、室內環境品質相關政策之參考。

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壹、出國目的

2019 年年底，新冠肺炎開始肆虐全球，根據 WHO 的統計，新冠肺炎至少已經造成全球 650 萬人死亡，另一方面，聯合國政府間氣候變遷專門委員會（IPCC）每隔約六年發布一次氣候變遷科學評估報告（IPCC Assessment Reports, AR），近期於 2023 年 3 月 20 日發布第六次評估報告(AR6)之總結報告，明白揭示目前全球已比工業化前升溫約 1.1°C，如果要達到 2015 年巴黎協定將溫升控制在 1.5°C 的目標，2030 年的排放量需較 2019 年降低 43%，顯示未來 10 年，全球都將面臨比現今更加嚴格的減量要求。不論是後疫情時代的健康議題或是建築節能議題，都與本所綠建築、智慧建築及綠建材等政策息息相關，因此，本所派員參加 Healthy Buildings 2023 健康建築研討會，蒐集建築節能、健康建材、室內環境品質改善技術與發展經驗等相關資訊，並瞭解國際間目前關注的議題與未來發展趨勢，以作為本所推動相關業務之借鏡與參考，期能對於本所推動綠建築、智慧建築、綠建材等業務有所助益。

貳、出國行程

日期	活動內容	備註
6月9日 (星期五)	台灣出發	路程
6月10日 (星期六)	抵達德國亞琛(Aachen)	路程
6月11日 (星期日)	會議第 1 天-參加 Healthy Buildings Europe 2023 Conference 研討會開幕式、專題演講會議、晚宴	
6月12日 (星期一)	會議第 2 天-參加 Healthy Buildings Europe 2023 Conference 分組研討會、海報展覽	
6月13日 (星期二)	會議第 3 天-參加 Healthy Buildings Europe 2023 Conference 分組研討會、產品展覽	
6月14日 (星期三)	會議第 4 天-參加 Healthy Buildings Europe 2023 Conference 分組研討會、閉幕式 拜會亞琛工業大學建築系及能源研究中心	
6月15日 (星期四)	德國-台灣	路程

參、Healthy Buildings 2023 健康建築研討會簡介

一、會議主辦單位簡介

本國際研討會是室內空氣品質系列研討會的第 18 屆會議，第 1 屆會議於 1988 年在瑞典斯德哥爾摩舉辦，該會議係由國際建築與營建研究創新聯盟(International Council for Research and Innovation in Building and Construction, CIB)支持，之後，每 2 年舉辦 1 次健康建築研討會。本屆會議是德國亞琛工業大學 (Rheinisch-Westfälische Technische Hochschule Aachen, RWTH) 和亞琛工業大學附設醫院在國際室內空氣品質和氣候協會(International Society of Indoor Air Quality and Climate, ISIAQ) 的贊助下共同舉辦，本屆會議的主題是「超越學科界限(*Beyond Disciplinary Boundaries*)」，其意涵在強調以跨領域的科學視角去看待和思考健康建築的議題，並共同尋找解決方案，其所涉及的領域涵蓋醫學、環境科學、建築、機械、資訊、電機、人工智慧、社會科學等。

二、會議舉辦地點

本會議舉辦地點在德國亞琛(Aachen)，該城市位於德國與荷蘭、比利時交界處，位處歐洲中心位置，有歐洲心臟之稱，從比利時布魯塞爾搭乘高鐵到德國亞琛約僅 1 個小時，從法國巴黎出發，也僅約 2.5 個小時，因此大會主辦單位在官方網頁，特別建議來自歐洲的參與者，盡量搭乘火車、高鐵等運具，盡量避免搭乘飛機，以降低旅運過程的碳排。另外，亞琛為德國科研重鎮，亞琛工業大學素有「歐洲的麻省理工」之美譽，整個亞琛可以說是一個大學城，該城市人口約為 25 萬人，亞琛工業大學師生人數則超過 5 萬人。

本次會議舉辦場所為「Das LIEBIG」(圖 1)，該處並不是一般的會展中心或大學會議廳，Das LIEBIG 原本是一個營運近一百年的屠宰場，屠宰場在 2002 年關閉後，這個充滿歷史感的老建築，變身為一個可以舉辦活動和展覽的文創空間，成為歷史建築延壽、活化、再利用的具體案例，主辦單位選擇這個場所，也具體呼應了研討會永續、低碳的訴求。



圖 1.會議場所 Das LIEBIG

(圖片來源:本報告拍攝)

肆、會議開幕式及展覽

一、會議開幕式

本次研討會開幕式於 Das LIEBIG 主演講廳舉辦，大會安排了一個小時的小型音樂演奏會，之後由會議主席 Schweiker 教授等人致詞(圖 2)，Schweiker 教授是亞琛工業大學附設醫學院，職業、社會和環境醫學研究所教授，Schweiker 教授除了歡迎來自全球 38 個國家的 434 位與會者前來參加會議，也特別強調後疫情時代，人類社會面臨氣候變遷及環境醫學上的重大挑戰，必須依賴跨學科間的合作與理解，才能為健康環境尋找創新的解決和實踐方案。大會在第一天晚上也安排了歡迎晚宴(圖 3)，晚宴是自由參加，參加者需額外繳交 35 歐元，晚宴地點安排在亞琛工業大學。



圖 2.研討會開幕致詞
(圖片來源:本報告拍攝)

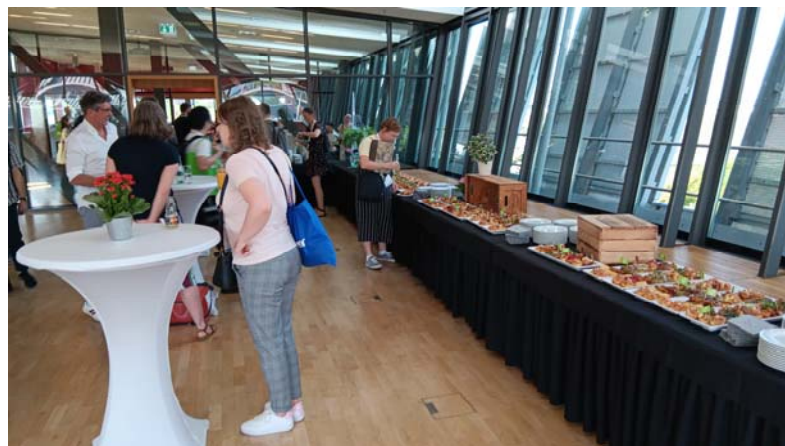


圖 3.研討會晚宴
(圖片來源:本報告拍攝)

二、論文海報展覽及產品展覽

本次主辦單位於會場周邊安排論文海報展覽(圖 4)，共計有 44 篇論文以海報方式展覽，作者大多會在海報前協助解說，現場互動熱絡。另外，大約有 10 家儀器廠商在現場擺設攤位參展，參展的廠商主要是室內空氣品質淨化及量測儀器，其中位於美國明尼蘇打州的 TSI 科技公司(Toson Technology)展覽的產品最為豐富(圖 5)，該公司主要是生產及研發空氣中微粒子檢測儀器(Particle Counter)，包括手持式、桌上型等，可用於監測半導體無塵室、藥廠無菌室等場所之空氣品質，另外也有針對粉塵(Dust)、氣溶膠(Aerosol)、揮發性有機物質的監測儀器。



圖 4.研討會論文海報展覽
(圖片來源:本報告拍攝)



圖 5.TSI 科技公司之儀器設備展覽攤位
(圖片來源:本報告拍攝)

伍、會議重要內容概述

一、需量反應應用於建築節能

根據統計，住宅及商業建築大約耗去全球 40% 的能源，供暖、通風，及空調大約占去商業類建築能源消耗的 4 成以上(詳圖 6)，這個比例因氣候不同而有所差異。需求面管理(Demand Side Management, DSM)，又稱需量反應(Demand Response, DR)，即是透過管理措施或是控制技術，減低特定低電價時段用電需求的方法，讓電力系統在較低成本下有效舒緩短期供電緊張的窘境，提升整體電力系統的運營效率。

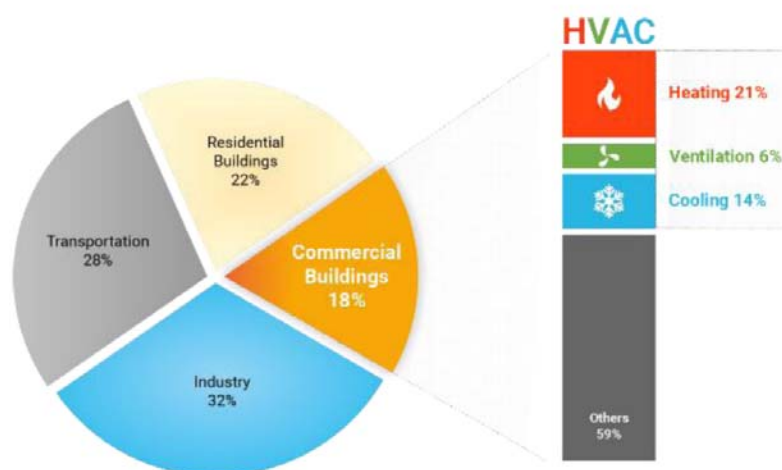


圖 6.全球住商部門能源消耗占比

(資料來源:Ahmet Köse et al, Practical Demand Side Management: One Day Case Study, Healthy Buildings 2023)

需量反應有個很重要的應用前提，就是時間電價的制度，大多數歐洲國價的電價是每小時都不同(Hourly-based Market Prices)，這個價格是根據每個小時能源生產量和消費量決定。以歐洲的能源價格而言，2020 及 2021 年由於新冠肺炎疫情的肆虐，且 2021 年的歐洲冬天異常溫暖，歐洲對於能源需求明顯降低，但是到了 2022 年，疫情逐漸緩和，且遇上烏俄戰爭，歐洲 2022 年電價相較於 2021 年幾乎漲了一倍(圖 7)，2022 年 8 月份波羅的海國家愛沙尼亞最貴的電價，是晚上六點到七點的電價，一度電約為 4 歐元。

Average price (EUR/MWh) comparison for last two years among several countries in Europe

	2021	2022
Estonia	86.73	192.82
Finland	72.34	154.04
Germany	96.85	235.45
France	109.17	275.88

圖 7.歐洲國家 2021 年及 2022 年平均電價的變化

(資料來源:Ahmet Köse et al, Practical Demand Side Management: One Day Case Study, Healthy Buildings 2023)

本次研討會，愛沙尼亞的研究者提出了需量反應的實際應用(圖 8)，由於早上十點到下午三點是該國電價最便宜的時段(詳圖 8 紅色虛線段)，且對商業建築而言，該時段使用人數最多，因此，該時段空調機組負荷予以加大(如圖 8 柱狀圖)，到了下午電力負荷會降低，但是到了下午六點至七點間，由於電力價格大幅上漲，每度電大約 4 歐元(如圖 3 紅色虛線)，超過其它時段十倍以上，因此此峰值前，負載自動額外增加以補償峰值時負載的降低(如圖 8 柱狀圖綠色部分)，而在下午六點至七點間，則大幅降低附載(如圖 8 柱狀圖橘色部分)。當過了峰值，負載又會額外增加，以提高舒適度，根據計算，需量反應的演算法可以把峰值的用電量降低 26.8%，這對於維持電網的穩定性和平衡而言非常重要，而且經過這樣的調整後，室內的溫度，仍可維持舒適度(溫度變化如圖 8 紫色線段)。研究也指出，傳統的建築空調系統並沒有類似智慧化的設計，而係依據固定的運轉模式操作，結合人工智慧的需量反應系統，非常適用於每小時能源價格變動較大的國家，而且需量反應系統主要係透過編寫程式達成，無需投入大量的建置成本，且需量反應相較於能源管理系統，可以更為節省電費。

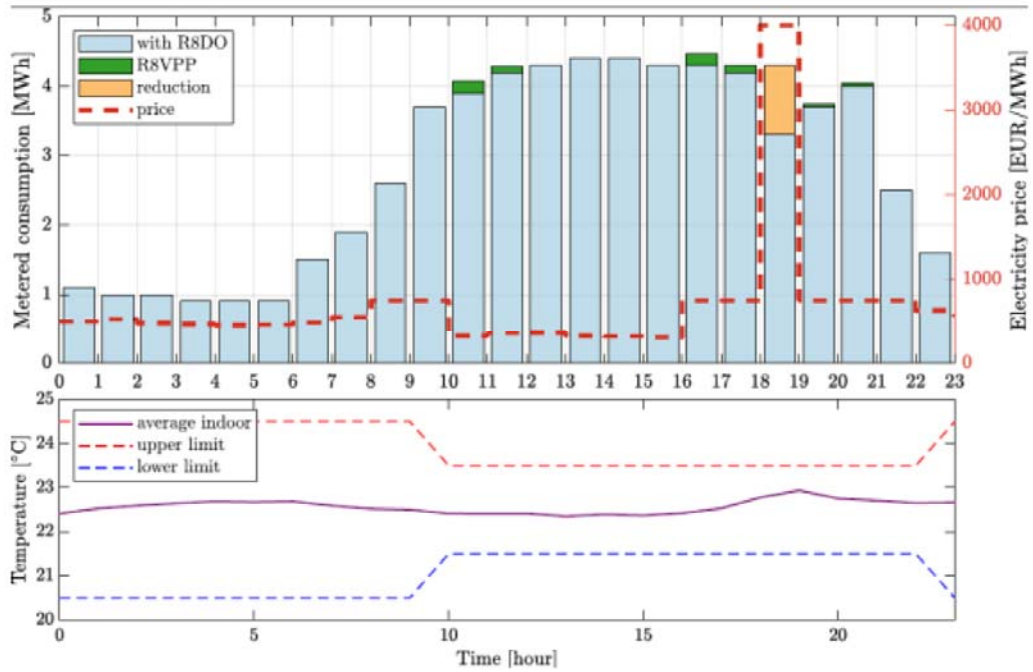


圖 8.需量反應實際應用之效益圖

(資料來源:Ahmet Köse et al, Practical Demand Side Management: One Day Case Study, Healthy Buildings 2023)

研究指出，由於人工智慧、物聯網(Internet of Things, IoT)、類神經網路(Artificial neural network, ANN)等技術的成熟，可以實現將空調系統進行最佳化的調控，在不損及舒適度的前提下，智慧化的空調控制系統可以節能至少20%，這類的設計，大多透過屋內不同位置設置感知器，感知屋內溫度、濕度、人數等參數，參數回饋到智慧型演算模型，進而控制空調的風量及主機頻率等，如果這個演算法又加入了時間電價這個變數，除了降低能源需求以外，還可以達到需量反應的效果，而如果這個演算模型進一步具有深度學習的能力，例如透過累積之大量數據，進行深度學習，以預測不同時段的人流、時間電價、溫度、外部氣候等，並連動空調運轉，則可以進一步提高空調效率並優化電費及室內舒適性，這一類人工智慧結合需量反應的技術，應用於商業類建築，或是採用分散式空調系統的大尺度空間，節能潛力更大，因為這類建築，一天內使用的時間或人流的高峰並不是持續的，因此需量反應可以有更好的機會可以去將負載轉移到其他適當時段。

二、木製建材乙醛逸散之研究

木材一般被視為天然的材料，木造建築或家具也被認為有助於全球的淨零轉型，但是，實際上木材卻是室內揮發性有機化合物 VOCs 來源之一，不僅是木材大多會使用黏著劑，也因為木材表面如果接觸相關化學物質，也會逸散出 VOCs。乙醛(Acetaldehyde)是木材較常逸散出的揮發性有機化合物，它被世界衛生組織癌症總署 IARC (International Agency for Research on Cancer of the World Health Organization)歸類為人類致癌物質，而木材之所以會釋放乙醛，主要的原因是木材接觸到乙醇(酒精)，不論是油漆、黏著劑、清潔劑都可能有酒精成分，而木材中有乙醇脫氫酶(Aldehyde Dehydrogenase, ADH)成份，會將乙醇轉化為乙醛。

在疫情期間，酒精被大量使用於室內，日本學者的研究顯示以每平方公尺 130 毫升的比例，將酒精噴灑在木製桌椅，或以酒精進行木製家具的擦拭，會造成乙醛濃度的上升。研究者以濃度 70%的酒精噴灑在不同材料的木板上，並利用尺寸為 1 立方公尺的不鏽鋼環控箱進行空氣中乙醛濃度的檢測(詳圖 9 及圖 10)，環控箱溫度控制在 26 度，濕度控制在 60%，換氣率為 0.5h⁻¹，負荷率為 1.41 m²/m³。取出的空氣再以液相層析儀 HPLC(High-Pressure Liquid Chromatography)及氣相層析質譜儀 GC/MS(Gas Chromatography - Mass Spectrometry)進行分析。

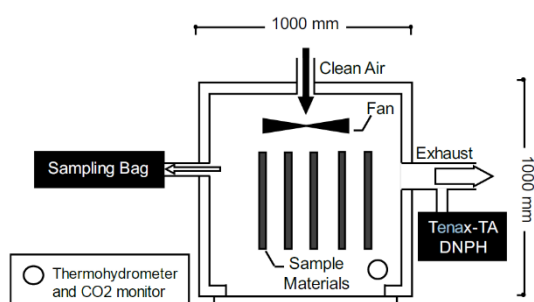


圖 9.不鏽鋼環控箱平面圖

(資料來源: Nami Akamatsu et al, Effect of Applying Alcohol to Wooden Surfaces on VOC Emissions and Perceived Air Quality, Healthy Buildings 2023)



圖 10.環控箱內部情形

(資料來源: Nami Akamatsu et al, Effect of Applying Alcohol to Wooden Surfaces on VOC Emissions and Perceived Air Quality, Healthy Buildings 2023)

經過檢測，乙醛濃度超過日本厚生勞動省所定的標準($48 \mu\text{g}/\text{m}^3$)，尤其是日本柳杉(Japanese cedar)及日本柏(Japanese cypress)，乙醛上升速度最為明顯，其中柳杉逸散出之乙醛濃度高達 $9327.8 \mu\text{g}/\text{m}^3$ ，柏樹高達 $8757.8 \mu\text{g}/\text{m}^3$ 。

但是如果樹種是日本椴樹(Japanese Lime)和膠合板(Plywood)，乙醛濃度則較低，原因是因為樹種不同，其乙醇脫氫酶(ADH)的含量也不同，另外如果是經過熱處理的加工木材，也會讓 ADH 的含量變低。

三、雙層外牆節能效益

根據歐盟統計，在歐盟國家中有超過 1/3 的建築物屋齡超過 50 年，這些建築物僅約有 3% 具備有節能效益的外殼系統(Efficient Building Envelope)，為了要符合歐盟 2050 年建築脫碳(Decarbonized)及全面提高能效的目標，各種節能外殼系統被廣泛研究，其中雙層外殼被視為一種可行的解決方案，相較於主動建築(Active Building)主要依賴機械通風及空調去維持室內熱舒適度，被動建築(Passive Building)則透過建築設計和結構優化來提高建築熱舒適性，其中外殼的節能設計是被動建築的主要手法。

為了提高建築外殼節能效益，挪威學者進行了一個雙層外殼系統(Second-Skin Façade, SSF)的研究，該研究在挪威科技大學建立實驗屋(圖 11)，兩個相同的實驗屋尺寸為:長 4.2 公尺、寬 2.4 公尺、高 3.3 公尺，實驗屋外面均設置獨立的第二層外殼，外殼空間為 210 立方公尺，第二層外殼僅南邊方向留設窗戶開口，且兩實驗屋第二層外殼構造彼此不連通，兩個實驗

屋可視為條件相同且獨立的個體，研究同時針對兩實驗屋進行相同量測與模擬，兩者的表現幾乎在誤差範圍內，可確認研究的可信度。

該實驗的第二層外殼使用高分子聚合纖維材料，該材料具備柔軟、彈性、輕量等特點，第一層傳統外殼和第二層中間，有一層空氣層，空氣層設置可控制通風量的通風口和進風口，可調節空氣層的溫度。

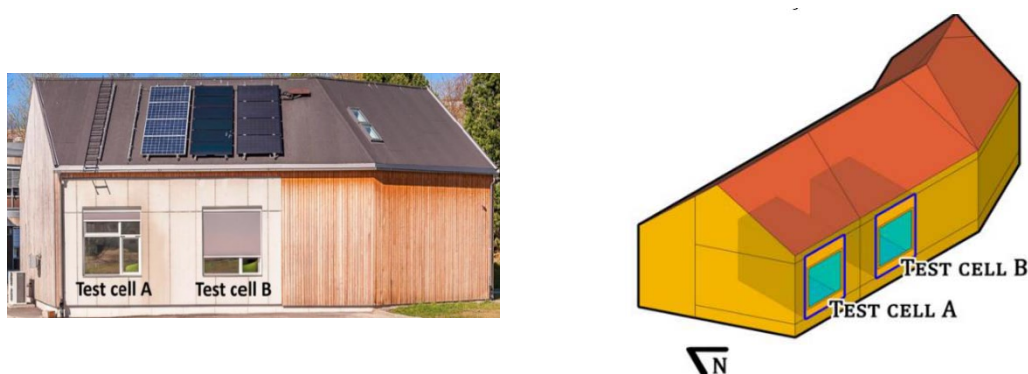


圖 11.雙層外殼建築實體照片及 3D 模型圖

(資料來源: Niloufar Mokhtari et al, ZEB Test Cell Laboratory digital twins: assessing the textile SSF benefits in the Nordic region, Healthy Buildings 2023)

研究量測了有雙層外殼的實驗屋和無雙層外殼的實驗屋，發現全年度的採暖及制冷能耗可以降低 21.4%，不過，本研究實驗屋僅留設南向開口，並未考量晝光照明及視覺舒適性的考量面向。

四、環控箱尺寸之比對研究

對於揮發性有機化合物(Volatile Organic Compounds, VOCs)而言，長期暴露的逸散情境和初始逸散情境對於健康風險評估都不可或缺，例如:油漆的長期逸散對於居住者較為重要，但是油漆開封後的初始逸散對於施工現場人員的健康風險評估就較為重要，國際上對於環控箱尺寸並沒有統一的規定，因此，德國學者Luise Klein等人針對環控箱尺寸對於受測材料的初始逸散速率和長期逸散速率的影響進行分析，研究顯示(如圖12)，採用3種不同尺寸的環控箱進行萘(Naphthalene)及1,1,3-三甲基環己烯酮(Isophorone)化學物質定

量分析，初始逸散濃度受到環控箱尺寸影響甚大，到了24小時以後，濃度值雖然接近，但是仍有不能忽略的差異，這主要的因素是因為大型環控箱的換氣率、負荷率(受測材料面積和環控箱體積之比例)、溫度、濕度等，都較為接近真實狀態，因此，該研究建議盡量使用大尺寸環控箱，但若檢測微型物體，非使用小尺寸環控箱時，可以透過降低負荷率及加大換氣率來避免高估初始逸散濃度。

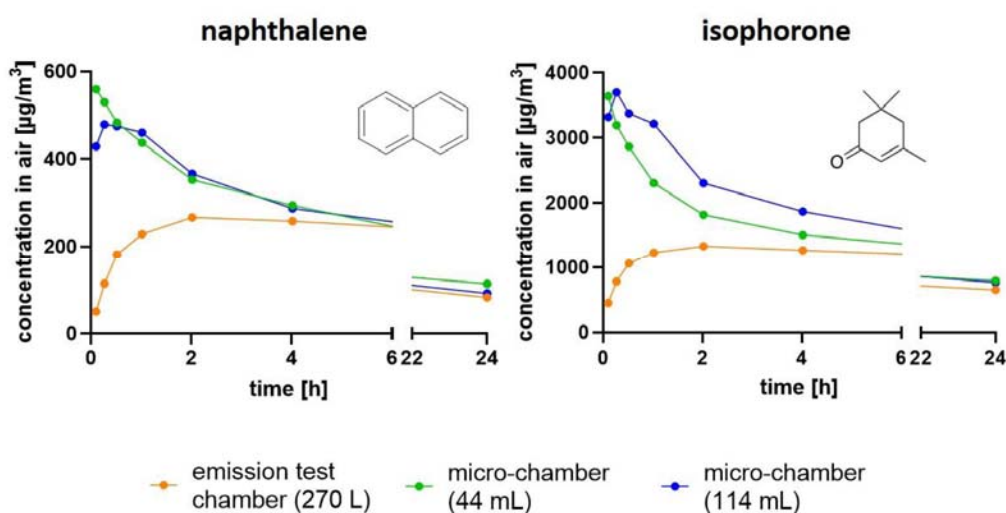


圖12.不同尺寸環控箱對實驗結果之影響

(資料來源: Luise Klein et al, Chamber comparison for the determination of initial VOC emissions from consumer products, Healthy Buildings 2023)

陸、會議閉幕式及頒獎

本屆會議閉幕式在 6 月 14 日下午召開，首先由會議主席總結相關成果，本次會議共有 388 篇摘要投稿，參加人數為 434 人，大會並且統計了各國參與人數，人數最多的十個國家依序為:德國、美國、荷蘭、丹麥、英國、芬蘭、日本、法國、義大利、比利時，而台灣僅 1 人參與(詳圖 13 最右側)。另外，大會也在閉幕式舉辦頒獎儀式，獎項包括最佳海報論文獎(詳圖 14)、最佳學生海報論文獎、最佳論文發表獎、最佳學生論文發表獎，較為特別的是環保旅程獎(Eco Travel Award)(詳圖 15)，鼓勵採取低碳方式參與會議的與會者，例如購買碳中和機票、住宿碳中和旅館，並在碳中和餐廳用餐等。



圖 13.各國參與人數統計
(圖片來源:本報告拍攝)



圖 14.閉幕式頒發最佳海報論文獎



圖 15.閉幕式頒發環保旅程獎

(圖片來源:本報告拍攝)

柒、拜會亞琛工業大學建築系及能源研究中心

本次出訪安排拜會亞琛工業大學（Rheinisch-Westfälische Technische Hochschule Aachen, RWTH）建築系及能源研究中心，亞琛工業大學是德國最大的理工大學，有6位校友得到過諾貝爾獎，該校有9個學院，該校也是德國僅有的三所擁有醫學院和附設醫院的理工大學，另兩所為慕尼黑工業大學及德勒斯登工業大學，該校亦致力於國際化，與台灣國立清華大學、台灣科技大學、國立台灣大學、國立交通大學、國立成功大學等校締結為姊妹校。

亞琛工業大學建築系創立於1878年，該系有大學部、碩士班、博士班，研究類組包括建築設計、房地產發展、規劃理論、城鄉發展、景觀設計、藝術史、歷史建築、視覺藝術、空間設計、結構設計、文化遺產等，該系非常重視實作，除了模型製作、石膏雕塑、金屬雕塑、還包括石雕及木工，該系接待人員特別介紹該系的木工實習場(圖16)、石雕實習場(圖17)、研究生工作室，並介紹該校研究生研發的再生透水磚，及大學部同學手繪素描作品，本次參訪，也向該系簡介本所近幾年研究成果，並互留聯繫管道，以利後續交流合作。

本次出國亦參訪亞琛工業大學能源研究中心，並參觀其大型環控箱(圖18)，其環控箱與我國常見進行逸散試驗之環控箱不盡相同，我國之環控箱雖然可以控制溫度濕度，但是無法局部調整艙體壁面溫度和材質，也無法調整進氣出氣的開口位置，然而，實際上一個建築物其表面材質和各面的溫度不會相等，表面溫度受日照影響而不同，因此能源研究中心的環控箱壁面是由很多不同單元所構成，因此可以精細控制每個單元的溫度，也可變換材質，另外還可以模擬不同空調形式、出風位置、通風量、換氣率、熱交換形式、風扇形式，因此該艙體可以說是多功能的，不僅可以進行相關有機物質檢測，還可以進行熱舒適度、節能、空氣淨化等研究，另外也可檢測空調中冷媒洩漏情形，並據以研發替代材料，由於過去常用的冷媒是氟氯碳化物(CFC)，但其中的氯會破壞臭氧層，已經被大部分國家禁用，而以氫氟碳化物(HFC)取代，但HFC屬於溫室氣體，會使溫室效應增強，促進全球暖化，因此該實驗室也在嘗試研發的新的冷媒材料，而不同的冷媒在不同的溫度及壓力下，會有不同的逸散行為，該環控箱也可以進行相關模擬。



圖16.建築系木工實習場



圖17.建築系石雕實習場

(圖片來源:本報告拍攝)



圖18.亞琛大學能源研究中心大型環控箱

(圖片來源:本報告拍攝)

捌、心得與建議

本次參加 Healthy Buildings 2023 健康建築研討會及參訪，獲致心得及建議如下：

一、心得

(一)健康建築研究須結合跨領域專業

本次研討會可以發現，健康建築的研究較少是由單一專業背景的專家所單獨完成，許多是跨領域的專家合作進行，其中有許多是以環境醫學領域的專家為主幹，結合建築、毒物學、公共衛生、心理學、機械、土木等領域專家進行研究，可見跨域合作及統整對於健康建築領域的研究尤為重要。

(二)歐洲國家高度關切建築隔熱議題

在建築節能領域，一般而言，亞熱帶國家會較重視建築隔熱及遮陽，北溫帶國家往往較重視保溫，且亞熱帶國家建築耗能的高峰是在夏季制冷，北溫帶國家建築耗能高峰則在冬季採暖，不過，本次研討會，有許多歐洲國家不約而同地進行夏季的建築隔熱研究，包括雙層外殼、隔熱屋頂、隔熱漆、相變材料、高反射材料、節能玻璃等，雖然隔熱與保溫是一體兩面的，但是研究聚焦的方向卻都在夏季隔熱而非冬季保溫，這引起筆者好奇，經與一位瑞典學者請教後，該學者表示，整個歐洲社會對於冬季低溫，長久以來已經有一套因應之道，但是隨著全球暖化的氣候變遷，即使在中、北歐地區，夏季的高溫逐年攀升，然而，這些國家對於夏季高溫，過去並沒有做好準備，在德國及德國以北的國家，住宅幾乎沒有冷氣設備，即使是公共運輸系統的公車、火車、高鐵也大多是沒有冷氣，僅有暖氣，因此，夏季的高溫，已經讓歐洲人幾乎達到忍受的臨界，因此相關的研究也就蓬勃發展。

二、建議

(一)加強全尺寸環控箱相關資料蒐集、研究及產學合作宣導

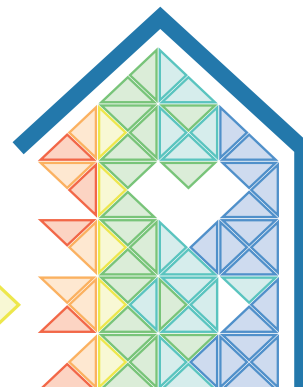
國際上對於揮發性有機化合物的檢測，有朝向全尺寸檢測的趨勢，雖然成本較高，但是較能模擬真實空間的狀態，本所亦有建置全尺寸的環控箱，未來可以持續蒐集國外全尺寸環控箱的應用案例，規劃適當的研究課題或檢測服務，並加強業界的推廣，以提高全尺寸環控箱對於大型家具、複合式系統建材(如隔音牆系統、隔音地板系統等)檢測量能。

(二)以人工智慧及物聯網技術，應用於改善室內環境品質及建築節能，已成為國際主流趨勢，建議加強相關研究。

本次研討會有頗高比例的研究是有關人工智慧及物聯網技術的應用，包括具有人工智慧的設備或管理系統。由於室內環境品質和建築節能的理論基礎已經相對成熟，而這些想法要轉化成可普遍應用於現實生活中的解決方案，不可避免必須依賴新的科技技術，例如人工智慧和物聯網，舉凡系統的建模(Modeling)、控制(Control)、最佳化(Optimization)，都可以隨著創新科技的發展得到提升，因此本次研討會可以看到不少演算法研究、控制晶片製作、程式語言技術、感知器傳輸等議題的論文發表，建議未來可針對人工智慧和物聯網等相關核心技術進行資料蒐集或研究。



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Cite contributions as:

Authors (2023). Title of Contribution. In: Schweiker, M., van Treeck, C., Müller, D., Fels, J., Kraus, T. , Pallubinsky, H. (Ed.), Proceedings of Healthy Buildings 2023 Europe, Aachen, Germany, p. XX-XX

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From the President of Healthy Buildings 2023 Europe

Dear all, welcome to Healthy Buildings 2023 Europe, welcome to Aachen!

Healthy Buildings 2023 Europe is the continuation of the renowned ISIAQ Healthy Buildings conference series travelling around the world and connecting international and local experts.

The last decades offered a multitude of knowledge gained and solutions developed within individual disciplines. The sensible application thereof however requires a holistic understanding of interdependencies between and across disciplines. At the same time, current crises, such as climate change and the COVID-19 pandemic, show the need for inter- and transdisciplinary collaboration to shape the future of healthy and stimulating built environments – a task all of us, organizing and attending this conference are striving for. This rationale also led to this year's conference theme „Beyond disciplinary boundaries – Transdisciplinary perspectives on multisensory stimulation for innovative and creative solutions in a post-Covid era” and we hope you will engage with participants beyond your own disciplinary background to exchange knowledge, methods and ideas.

We, the organizing committee, are honoured by the extraordinary interest demonstrated by more than 400 registered participants, over 390 abstracts submitted leading to 256 contributions presented as oral or poster presentations, 13 interactive workshops, 6 keynotes and 1 panel, all taking place during the 3 main conference days. This interest also shows the need and desire to get together on-site, to support established contacts and to create new ones, to present and to discuss the latest results and to give and to receive feedback from peers. These numbers and the desired compactness also provide some challenges, e.g., with respect to the time available for presentations and poster sessions. We made the greatest effort to accommodate everyone's wishes and hope you will enjoy your conference visit.

We would like to thank all the volunteers and our sponsors; such event would not be possible without their support. At the same time, we already thank all of you for your contributions and active participation in this conference to make it a great success for everyone.

Also, on behalf of the organizing committee

Marcel Schweiker,

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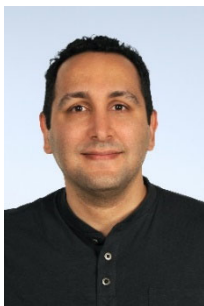
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- Marc Syndicus, RWTH Aachen University, Aachen, Germany
- Martin Täubel, Finnish Institute for Health and Welfare, Kuopio, Finland
- Despoina Teli, Chalmers University, Gothenburg, Sweden
- Martin Thalfeldt, Tallinn University of Technology, Tallinn, Estonia
- Liselotte TINEL, IMT Nord Europe, Douai, France
- Jørn Toftum, Technical University of Denmark, Lyngby, Denmark
- Linda Toledo, University of Strathclyde, Glasgow, United Kingdom
- Fatih Topak, Middle East Technical University, Ankara, Turkey
- Marianne Touchie, University of Toronto, Toronto, Canada
- Erik Uhde, Fraunhofer WKI, Braunschweig, Germany
- Donna Vakalis, University of British Columbia, Vancouver, Canada
- Wouter van Marken Lichtenbelt, Maastricht University, Maastricht, Netherlands
- Christoph van Treeck, RWTH Aachen University, Aachen, Germany
- Marika Vellej, La Rochelle University, La Rochelle, France
- Christian Vering, RWTH Aachen University, Aachen, Germany
- Marie Verrielle, IMT Nord Europe, Douai, France
- Conrad Völker, Bauhaus-University Weimar, Weimar, Germany

- Andreas Wagner, Karlsruhe Institute of Technology, Karlsruhe, Germany
- Aneta Wierzbicka, Lund University, Lund, Sweden
- Gerhard A. Wiesmueller, Zentrum für Umwelt, Hygiene und Mykologie Köln, Köln, Germany
- Leif Wirtanen, Ramboll Finland, Espoo, Finland
- Peder Wolkoff, National Research Centre for the Working Environment, Copenhagen, Denmark
- Wenping Yang, National Research Council Canada, Ottawa, Canada
- Jaafar Ibrahim Younes, American University of Beirut, Sarafand, Lebanon
- Xinxian Yu, The Chinese University of Hong Kong, Hong Kong, Hong Kong
- Xiaolei Yuan, Aalto University, Espoo, Finland
- Luca Zaniboni, Technical University of Denmark, Kgs. Lyngby, Denmark
- Wim Zeiler, TU Eindhoven, Eindhoven, Netherlands
- Jiaxu Zhou, University College London, London, United Kingdom
- Yiding Zhou, The Chinese University of Hong Kong, Shatin, N. T., Hong Kong
- May Zune, Brunel University London, London, United Kingdom

附錄二 會議議程

Start	End	Sunday	Monday	Tuesday	Wednesday	Start	End
08:00	08:15					08:00	08:15
08:15	08:30					08:15	08:30
08:30	08:45					08:30	08:45
08:45	09:00					08:45	09:00
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19:45	20:00					19:45	20:00
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