CASE25

Advancements in Sustainable Engineering

Book of Abstracts

Frederick University, Limassol, Cyprus
11–12 September 2025

Table of Contents

Arch01 - Design for Green Spaces

CASE25_Arch_E_2 — “aphaeresis”: sustainable pedagogy in architecture

Constantinos Petrakos[1]*
[1] Department of Architecture, University of Patras, Patras, Greece
*E-mail: petrakosk@gmail.com

Abstract.
Architecture is traditionally seen as a process of addition—building upon what already exists. However, the concept of unbuilding, or removal, has been largely absent from architectural discourse, despite its historical presence in the field. This research challenges the conventional understanding of architecture by proposing Aphaeresis—the act of intentional subtraction and removal—as a new design methodology and pedagogy. Rooted in a critical revaluation of architectural practice, Aphaeresis offers an alternative framework for approaching the built environment, one that sees the removal of existing structures as a valuable process in its own right. This thesis explores Aphaeresis through a review of 20th-century architectural theories, as well as more recent urban theories developed after the 2007-2008 financial crisis, including minor architecture, Abstraction, and subtraction. Empirical research is carried out through the analysis of two case studies: the Tudela-Culip Restoration project in Cap de Creus (early 21st century) and the Restoration of the Acropolis Hill (early 19th century), examining both the narrative and design processes of each. These case studies reveal how moments of crisis, whether economic, cultural, or environmental—have historically catalyzed architectural innovation, leading to the development of new methodologies such as Aphaeresis. This study argues that Aphaeresis challenges the notion of architecture solely as an act of addition, urging architects to embrace removal as a transformative tool to address the urban complexities of today and to align design with evolving cultural values.

CASE25_Arch_I_03 — Interactivity of natural and physical spaces in architectural design

Demetris Economides and Marios C. Phocas[1]*
[1] Department of Architecture, Faculty of Engineering, Frederick University, Nicosia, Cyprus
[2] Department of Architecture, Faculty of Engineering, University of Cyprus, Nicosia, Cyprus
*E-mail: d.economides@frederick.ac.cy; mcphocas@ucy.ac.cy

Abstract.
The interplay between natural and physical spaces in architectural design is significant for creating pleasant, functional and sustainable, harmonious environments. Corresponding design principles emphasize this relationship by incorporating nature into the built environment to improve comfort, cognitive function and the experiential quality of spaces. The interactive nature of natural and physical spaces in architectural design is discussed based on three examples of architectural proposals made by the authors in the frame of respective European architectural competitions. The example of a university students hall traces the extension of the natural environment through the building on an autonomous storey level. Interactivity derives from the unification of the natural environment at different heights and the visual correlations of the spaces and their external circulation zones with the open green spaces. The example of a university department's building facilities features the elevation of a public green space in height. Interactivity refers to the unification of the public spaces of the building with the open space, as well as the possible accessibility of the latter from the city level and the private spaces from above. The example of a clinical centre for patients and friends features an interconnection of the primary spaces over an open atrium that acts as point of reference for all spaces of the building. In this case, interactivity of the spaces influences the experience levels of the users while accommodating daily activity and change at different rates, scales and types that take place. The examples showcase means to synthesize natural and physical spaces with increased adaptive interactivity in fostering a deeper interconnection between the users and their surroundings.

CASE25_Arch_I_07 — Urban Narratives In Cyprus: Exploring Commuting Behaviors And Infrastructure Challenges

Agni Gregoriou[1]

[1] PhD Candidate, Department of Architecture, Frederick University

Abstract

This study investigates commuting behaviors, challenges, and perceptions in Cyprus, focusing on how transportation choices and infrastructure quality shape daily mobility patterns. A detailed questionnaire was distributed across various regions of Cyprus to gather insights into commuting habits. Cyprus ranks fourth in the EU for cars per capita, with 658 cars per 1,000 inhabitants (2022), reflecting the country's heavy reliance on private vehicles. In Nicosia, the capital, traffic composition measurements from the Sustainable Urban Mobility Plan (SUMP) reveal that private cars make up 94-98% of vehicles, underscoring the city's strong dependence on cars and the limited use of alternative transport options. Similarly, SUMP data from Limassol shows that 91.8% of trips in the city are made by car, with minimal usage of public transport and cycling. These findings highlight the urgent need for the implementation of the Sustainable Urban Mobility Plan to reduce car dependency and encourage the use of more sustainable transport modes in both cities. This over-reliance on cars contributes to significant commuting stress, which has been well-documented in research. Factors such as long travel times, congestion, and unpredictable traffic create a persistent strain on commuters, leading to frustration, anxiety, and diminished productivity. As with other stress-inducing situations, commuting triggers the release of hormones like adrenaline and cortisol (McEwen, 1998; Shackman et al., 2011), initiating a fight-or-flight response that exacerbates emotional distress. In order to gain a comprehensive understanding of these issues within the Cypriot context, a thorough survey was administered across both urban and rural areas of Cyprus. This survey sought to investigate daily commuting patterns, transportation choices, and the factors influencing these decisions. It further examined commuters' preferences regarding routes, safety perceptions, and the quality of infrastructure, including roads, cycling lanes, and public transportation. By identifying key challenges such as traffic congestion and the limited availability of alternative transport options, the study aims to provide well-informed recommendations for the development of a more sustainable, efficient, and inclusive transportation system.

Keywords: Commuting behaviors, Urban Narratives, Mobility Challenges, Commuting Patterns

CASE25_Arch_I_09 — Local authorities as commons catalysts: Lessons from Bologna, Amsterdam and Prague

Penelope Vasquez Hadjilyra[1]

[1] Architect and Researcher, Frederick University, Cyprus

Abstract

Local authorities can play a catalytic role in enabling urban commons through participatory, regenerative, and legally grounded governance. To envisage pathways for municipalities seeking to facilitate commons-oriented planning, scholars must assess how diverse legal and political contexts shape the success and limitations of such initiatives. Drawing on case studies from Bologna, Amsterdam, and Prague, this paper analyzes how municipalities engage with citizens and private property owners to repurpose underutilized assets into collectively governed spaces. Bologna's collaboration pacts offer a model of formalized civic participation but face challenges of procedural inequality; Amsterdam's integrated commons strategy highlights infrastructural innovation while exposing vulnerabilities to market capture; and Prague's tactical urbanism exemplifies adaptive reuse but remains institutionally fragile. Building on these lessons, the paper argues that urban commons should be understood not as a fixed solution, but as a dynamic and negotiated governance practice that offers promising pathways for post-growth urban transformation. It further contends that municipalities like Limassol, which are navigating climate adaptation, housing precarity, and citizen disengagement, can benefit from adopting commons-oriented governance as a viable alternative that not only prioritizes collective stewardship, social inclusion, and ecological resilience, but also encourages citizens to care more deeply about the spaces they inhabit

CASE25_Arch_I_12 — Enhancing Urban Green Spaces in Cyprus: A Comparative Analysis of Local Planning Approaches Across Europe

Lora Nicolaou[1]; Agni Gregoriou[2]
[1] Frederick University, School of Engineering, Department of Architecture, Nicosia, Cyprus
[2] PhD Candidate, Department of Architecture, Frederick University

Abstract

This study examines how local plans in Cyprus address urban green spaces, comparing their approaches to those of seven European countries: Denmark, Greece, Spain, the United Kingdom, Italy, Malta, and the Netherlands. The selection of these countries is based on a combination of climatic, planning, and contextual factors. Italy and Spain, with their Mediterranean climate, offer relevant comparisons in terms of vegetation, water management, and urban greenery adaptation. The United Kingdom, Denmark, and the Netherlands provide insights into advanced planning frameworks and well-established policies on urban green spaces, highlighting best practices and effective governance models. Malta, sharing similar dimensions and climate with Cyprus, presents a particularly relevant case for comparison in terms of urban development challenges. Greece, as a neighboring country, offers a comparable legislative and cultural context. The research aims to identify best practices and areas for improvement by analyzing planning policies, regulations, and strategies related to green infrastructure. A comparative framework is developed to assess the strengths and weaknesses of each country's approach, leading to recommendations that could enhance Cyprus' urban planning framework. A key focus is the classification of urban green spaces, including public and private greenery, their typologies, functions, and contributions to sustainable urban development. These functions include ecological and environmental functions (air pollution reduction, CO_2 capture, temperature regulation, and soil protection), biodiversity support (providing ecological habitats and fostering species diversity), health and social benefits (enhancing recreational spaces, promoting well-being, and supporting therapeutic environments), economic value (increasing property values and attracting tourism), and aesthetic and architectural significance (enhancing the urban landscape). The role of private green spaces is particularly emphasized, recognizing their potential to complement public green areas in fostering biodiversity, improving microclimatic conditions, and enhancing urban livability. Additionally, the study explores not only how these spaces are categorized but also their governance, maintenance strategies, and integration into local planning mechanisms. Findings highlight critical gaps in Cyprus' local plans, particularly in terms of policy enforcement, long-term green space management, and the prioritization of private greenery. The paper concludes with recommendations advocating for a more comprehensive, proactive, and bold approach to integrating urban green spaces into local planning frameworks. By adopting successful strategies from other European contexts, Cyprus can strengthen its commitment to sustainable urban development and improve the quality of life for its residents.

Keywords: Urban green spaces, green space management, Private greenery, Urban planning standards, Typologies of urban green

Arch02 - Advances in Architectural Heritage

CASE25_Arch_E_1 — Conservation through Demolition: Sustainable Futures for Urban Heritage in Nafpaktos

Michail Papavarnavas[1]*

[1] Department of Architecture, University of Patras, Patras, Greece

*E-mail: mpapav@upatras.gr

Abstract.

The historic urban centre of Nafpaktos (Lepanto), a fortified city in Western Greece, presents a compelling case for rethinking conservation strategies through the lens of urban sustainability. Based on research conducted by the Department of Architecture, University of Patras, in two phases (2014–2015 and 2018–2021), this study examines the impact of modern development on the city's medieval defensive infrastructure. The analysis reveals that the city walls and their dry moats – once critical defensive elements – have been fragmented and obscured by contemporary construction.

This research proposes a radical yet historically sensitive intervention: the selective demolition of over twenty modern buildings that have encroached upon the moats. While seemingly counterintuitive, this strategy aims to restore the original spatial and historical coherence of the fortifications while addressing contemporary urban challenges. By removing these obstructions and reinstating the moats' continuity, the project not only safeguards a significant element of Nafpaktos' urban heritage but also introduces much-needed open green spaces within the dense cityscape.

Beyond heritage preservation, this intervention enhances environmental sustainability by improving air circulation, increasing permeable surfaces, and providing new public spaces that foster social well-being. It transforms the moats into vital ecological and communal assets, demonstrating how conservation can serve as both an act of recovery and renewal.

This case study argues for a conservation approach that extends beyond material preservation to embrace holistic urban sustainability. By integrating heritage protection with contemporary urban needs, it offers a forward-thinking model for reimagining historic cities in the face of modern pressures.

CASE25_Arch_I_04 — Shaping Resilient Futures - The Urban Planning Framework for Cyprus' Architectural Heritage

Gregoris Kalnis[1]*; Byron Ioannou[1]; Lora Nicolaou[1]; Agni Gregoriou[1]
[1] Department of Architecture, Frederick University, Nicosia, Cyprus
*E-mail: g.kalnis@frederick.ac.cy

Abstract.
The study explores the intricate balance between preserving Cyprus' architectural heritage and accommodating contemporary urban development. It addresses key issues related to urban resilience and cultural resilience, emphasizing how these concepts intersect in the context of Cyprus. Specifically, it examines how urban growth and environmental challenges are met with strategies that not only foster cultural adaptation but also promote community solidarity and the safeguarding of cultural identity. Demonstrating how urban growth and sustainability concerns can be reconciled, it highlights the legal frameworks governing Cyprus's architectural heritage. Central to this framework are the state's responsibilities in providing financial incentives, tax reductions, and technical assistance, alongside strategic regeneration schemes documented in Local Plans, Center Area Plans, and Policy Statements. Through case studies in key urban areas, the research highlights effective heritage conservation practices, addresses challenges such as gentrification and urban fragmentation, and offers strategies for preserving cultural identity while integrating sustainable contemporary urban development. Interviews with state planners, municipal representatives, and urban designers further reveal practical opportunities and constraints. The study exemplifies the New European Bauhaus pillars, emphasizing sustainability through building reuse, aesthetic continuity through respect for traditional architecture, and inclusion by revitalizing heritage sites as vibrant community spaces. In parallel, it examines Cyprus's planning strategies against broader sustainability agendas such as key UN Sustainable Development Goals, of safeguarding cultural heritage (SDG 11), fostering climate resilience (SDG 13), enhancing education (SDG 4), and promoting inclusive partnerships (SDG 17). Finally, the research underscores the significance of cultural identity as a key resource in sustainable urban rehabilitation and development, ultimately asserting that heritage preservation is not an impediment but an essential instrument for shaping Cyprus's future.

CASE25_Arch_I_06 — Combining Traditional Building Systems with Contemporary Technology: The Case of “Archontikon” in Akaki village, Nicosia.

Dr. Marios Pelekanos[1]

[1] Department of Architect Engineers, Frederick University, Nicosia, Cyprus

Abstract

Traditional construction methods in the lowland regions of Cyprus are predominantly defined by the use of load-bearing walls constructed from stone and mud bricks, complemented by ϐlat roofs supported by wooden beams. In the current context, where the reduction of the energy footprint of buildings, the optimization of bioclimatic function and the incorporation of sustainable materials are of paramount importance, there is a concerted effort to revive the construction principles inherent in these historical building systems, now enhanced by contemporary technological advancements. One notable initiative is the construction of the "Archontikon" on the periphery of Akaki village in Nicosia. The "Archontikon" (meaning "Mansion") is an auxiliary building adjacent to the Church of Ayios Iakovos Tsalikis, which is presently under construction. This single-story structure is characterized by load-bearing walls that are composed of stone at the base and mud bricks at the upper section. Slightly processed natural materials were extensively used in the structure, including local stones, handmade mud bricks, wood, traditional coatings and mineral wool. To a much lesser extent, modern materials such as steel sections, concrete and damp-proof breathable membranes, were also incorporated. The inner surface of the shell's walls was designed to include a narrow, naturally ventilated space, which accommodates thermal mineral-wool insulation panels and all necessary electro-mechanical installations. This lightweight structure was coated with traditional plaster applied to a metal mesh that is afßixed to a wooden frame. Furthermore, four windows located at the uppermost section of the hall primarily facilitate the natural extraction of hot air, thereby contributing to the cooling of the hall during the summer period. The energy footprint of the structure is signißicantly lower than that of a comparable conventional structure. Its exceptional energy efßiciency is attributed to the incorporation of both thermal insulation layers and the thermal capacity of the walls. Furthermore, 60% of the total volume of construction materials, including the foundation slab, is fully recyclable, while this ϐigure increases to 90% when the foundation slab is excluded.

CASE25_Arch_I_08 — On the Sustainability of Modern Architectural Heritage and Preservation.

Stella Evangelidou[1]*
[1] Department of Architecture, Frederick University, Nicosia, Cyprus
*E-mail: art.es@frederick.ac.cy

Abstract

In recent decades, growing environmental concerns in architecture have coincided with the increasing focus on the preservation of architectural heritage, particularly, that of the Modern Movement. Sustainability in architecture is viewed as a certain attitude and approach to design, construction and building operation, assessed by rating systems that apply the same criteria to both new and existing structures. For this reason, the discussion on the sustainability of the Modern architectural heritage is still considered by many to form an ambition and a paradox. This paper explores contemporary discourse on the sustainability and preservation of modern architectural heritage. It first examines architectural preservation through the key components of reuse, renovation, and restoration. The strategic design decisions toward such a task require a deep understanding of the Modern Movement's ideology, extending beyond stylistic concerns to material choices, social and aesthetic values, and the movement's innovative and technological agenda. Additionally, this study contextualizes sustainability within modernist-era perspectives on climate and economy. A particular focus is given to the modern architecture of the Mediterranean, analyzing how design elements such as brise-soleils, long cantilevers, materials, cross-ventilation, orientation, and landscaping contribute to sustainable principles. This analysis highlights the intersection between sustainability and cultural preservation, emphasizing the need to expand sustainability concepts when assessing modernist buildings. Finally, the paper presents contemporary case studies from various countries, showcasing projects that have successfully adapted modernist buildings through reuse, renovation, and restoration. These examples illustrate structural, energy, and regulatory challenges encountered in such interventions, offering insights into best practices for balancing sustainability with heritage conservation. By reframing sustainability in the context of modernist preservation, this study argues for a broader, more nuanced approach that integrates new assessment methods and design strategies to ensure the longevity of modern architectural heritage.

CASE25_Arch_I_10 — Geometrical determination of the typical house of Cyprus in the post war period

Nicos Georgiou[1]
[1]Department of Architecture, Frederick University, Nicosia, Cyprus

Abstract

The 1974 invasion and the occupation of 40% of Cyprus' land by Turkish troops created a massive number of 200,000 refugees who had to be immediately housed in the free part of the island. This led, in the following decades, to a significant growth in the construction sector, resulting in the creation of a very large housing stock, which was built quickly and aimed at addressing the immediate housing needs of the refugees.

This study geometrically examined the typologies of the houses that were built during this period. The analysis of these geometric data aims to define, with the greatest possible accuracy, the most common type of house constructed in Cyprus in the post-war period, which constitutes the core of the vast volume of housing stock currently exist on the island.

A similar study in a more general form, was published in an article in the journal "Energy and Buildings" by Panagiotou et al., who addressed the characteristics and energy behavior of the residential building stock in Cyprus, based on Directive 2002/91/EC (EPBD). The authors among other topics mentioned the total internal area of the most common type of house in the Cypriot building stock. The information presented in this article about the "average" Cypriot house is particularly relevant to the current study which follows a thorough analysis with a corresponding objective. In the present study, to define the geometric determination of the typical house in Cyprus, an extensive analysis of the housing stock data of the island was conducted. The research, presented below, is based on the data issued annually by the Statistical Service of the Republic of Cyprus and focuses on the entire building stock, as recorded from 1980 to 2016. As a conclusion of this study and the analysis of the dwelling stock of the Republic of Cyprus, the geometric data of what is referred to as the "typical house" of Cyprus during the examined period are provided.

Arch03 – Passive climatic design

CASE25_Arch_E_4 — Sustainable Renovation towards Net-Zero Modern Cultural Heritage: a Brutalist case study

Elias V. Messinas[1]*

[1] Department of Interior Design, Faculty of Design, Holon Institute of Technology (HIT), Holon, Israel

*E-mail: messinase@hit.ac.il

Abstract.

The sustainable renovation of historical buildings presents a unique set of challenges when addressing a balanced outcome between improving energy efficiency and preserving cultural heritage character and identity. European Union (EU) goals for net-zero carbon buildings by 2050, recognize the importance of developing comprehensive legal frameworks to guide stakeholders - architects, engineers, property owners, and policymakers - in adopting sustainable renovation practices to enhance energy efficiency, while respect architectural and historic value of cultural heritage buildings (ICOMOS, 2021).

The European Horizon program "SINCERE: The second life of modern period architecture: Resilient and adaptive renovation towards net-zero carbon heritage buildings" aims to elucidate the values of Built Heritage and provide the tools for optimizing the carbon footprint and energy performance of historic buildings, by utilizing innovative, sustainable, and cost-effective restoration materials and practices, energy harvesting technologies, ICT tools and socially innovative approaches, applied for the three main parts of buildings: structure, external envelope - opaque and transparent. The Building 3 of the Holon Institute of Technology (HIT) was built in 1972 in the Brutalist style of exposed reinforced concrete and distinct geometric forms. The four-storey structure serves as a pilot site for the SINCERE program. It was renovated and enlarged in 1992 with a metal roof utilizing the concrete flat roof, and in 2009 with the addition of an elevator shaft. The building provides today a mixed-use of spaces for administration (offices, meeting rooms), laboratories, conference hall, and synagogue. The pilot interventions include thermal insulating mortars, radiative cooling coatings and BIPVs in the roof glazed surfaces. Through H-BIM/H-Digital Twin tools the interventions will be evaluated for energy production and conservation, maintenance and overall performance. The educational context of the HIT campus, in collaboration with other SINCERE academic partners, provides opportunities to engage the academic community in the installation, monitoring evaluation and dissemination processes.

CASE25_Arch_I_01 — Enhancing Sustainable Heritage Documentation: Integrating Remote Sensing and HBIM

Argyris Fellas[1]*, Milton Demosthenous[2]
[1] Architectural Engineering Department, Frederick University, Nicosia, Cyprus
[2] Civil Engineering Department, Frederick University, Nicosia, Cyprus
*E-mail: art.fa@frederick.ac.cy

Abstract.
UNESCO and the European Community recognize heritage site protection and rehabilitation as essential policies which demand detailed and carefully planned restoration interventions for these structures. The Venice Charter together with other international guidelines mandates comprehensive documentation for all monumental structures before any restoration decisions can be made. This ensures the preservation of the site's architectural, historical and cultural integrity throughout the restoration process. A thorough analysis of the monument to be restored, including both geometric and structural analysis, is a crucial component of the documentation process. This analysis helps to identify the precise condition of the monument while providing a deeper understanding of the original construction methods. All the relevant historical documents along with archaeological evidence must also be collected during this process. Building materials evaluation combined with structural load transfer system analysis stands as a core element of the documentation stage. The analysis process also requires identification of current pathologies and vulnerabilities of the structure. Restoration projects often use monitoring systems to track developing pathology over time so that better informed restoration decisions can be made. This research examines heritage preservation methods through sustainable practices by analysing conventional documentation procedures and modern techniques. The combination of 3D scanning technology with photogrammetry allows fast and precise spatial data acquisition which results in minimal site disturbance. When combined with Heritage Building Information Modelling (HBIM), these methods produce an integrated digital archive which contains architectural, historical and material data. This integrated method enhances precision and efficiency and supports sustainable conservation practices while decreasing invasive procedures and reduces resource consumption. The adoption of these advanced, sustainable techniques will direct heritage preservation toward an environmentally responsible future, ensuring that the restoration practices are well informed, efficient and aligned with long term-term sustainability goals.

CASE25_Arch_I_02 — New European Bauhaus Challenges in Planning and Design Courses

Byron Ioannou[1]*; Gregoris Kalnis[1]; Lora Nicolaou[1]
[1] 1 Department of Architecture, Frederick University, Nicosia, Cyprus
*E-mail: b.ioannou@frederick.ac.cy

Abstract.

Sustainability and resilience have been foundational principles in urban design and planning education, predating their current prominence. This paper investigates the integration of UN Sustainable Development Goals (SDGs) and the evolving New European Bauhaus (NEB) principles within the Integrated Master's in Architectural Engineering curriculum at Frederick University. As a dedicated member of the UN SDG network and a national contact point, Frederick University provides a valuable case study for analysing the alignment of educational content with global sustainability agendas.

This research undertakes a multi-faceted approach. First, it establishes a detailed set of criteria for assessing higher education curricula, specifically tailored to the NEB's core tenets of inclusivity, aesthetics, and innovation. This criteria development is achieved through a thorough literature review, synthesizing current discourse on sustainable and inclusive built environments. Second, the study analyses the current content of urban design and planning courses within the aforementioned master's program. This analysis involves a systematic evaluation of the curriculum against the developed NEB criteria, aiming to quantify the degree to which these principles are currently embodied.

Finally, the paper proposes targeted improvements to strengthen the curriculum's alignment with NEB principles. This includes recommendations for enhancing the inclusivity, aesthetic considerations, and innovative aspects of the courses. By doing so, this research contributes to the ongoing evolution of architectural and planning education, fostering a new generation of professionals equipped to create sustainable, beautiful, and inclusive built environments. The findings of this research will be of interest to educators, policy makers, and professionals within the fields of architecture, urban planning and sustainability.

CASE25_Arch_I_05 — Digital Culture in Architectural Education: Exploring the Impact of Digital Tools on Architectural Design

Charalambos Solomou[1]

[1] Department of Architecture, Frederick University, Lefkosia, Cyprus

Abstract

Architectural education has traditionally relied on physical models, paper sketches drawings, and in-person critiques to impact essential skills and knowledge to architecture students. However, the digital revolution has introduced a variety of tools, innovating techniques and sustainable technologies that have fundamentally reshaped the educational landscape. Digital media including Computer-Aided Design (CAD), Virtual Reality (VR), Augmented Reality (AR), Building Information Modelling (BIM), Ai (Artificial Intelligent), has become essential to contemporary architectural pedagogy. The integration of digital culture into architectural education has transformed traditional design methodologies, reshaping how architectural concepts are generated, visualized, and communicated. This paper examines and re-evaluates the role and integration of digital media in architectural design education, with a focus on its impact on both the design process and the technical skills required of future architects. By analysing the influence of digital tools such as computational thinking and design, this study explores how these technologies foster innovation, sustainability, enhance collaboration, and support experiential learning. The findings highlight a shift from conventional design practices to a digitally driven approach that promotes experimentation and adaptability. This shift not only redefines the skill set necessary for emerging architects but also challenges educators to upskill and adapt curricula to "better" prepare students for an evolving architectural profession. This paper also underscores the importance of digital literacy in architectural education, arguing that the integration of digital media cultivates a new generation of architects equipped to address complex design challenges in a digital technology-driven world. This research adopts a qualitative approach, using an online questionnaire survey for data collection. The findings reveal ongoing efforts to explore and develop interfaces and programs aimed at enhancing digital design capabilities and fostering creative thinking. Additionally, the results show that while some educators have concerns about the early use of digital tools by students, more educators and students are willing to use them if they meet educational demands. Several digital tools for architectural analysis, design, and representation are examined to identify their appropriate implementation in both current and future architectural design studios. By tracing the historical trajectory of these technologies, this study highlights opportunities to reimagine the architecture studio and proposes strategic approaches for integrating digital literacy in ways that align with the evolving demands of architectural practice. Keywords: architectural pedagogy, education, digital tools, sustainable, technology

CASE25_Arch_I_11 — Large Span Sports Centres with Anti-Seismic and Bioclimatic Behaviour in Greece

Panayiotis Touliatos[1]*
[1] Department of Architecture, Frederick University, Nicosia, Cyprus
*E-mail: art.tp@frederick.ac.cy

Abstract.
Greece is one of the most earthquake-prone countries in Europe. In the second half of the twentieth century, there was a need for large covered spaces, mainly for sport's needs, such as gyms and swimming pools, but also for other operational purposes, such as shopping malls. The author of this article studied such structures, trying to achieve, in addition to anti-seismic behaviour, maximum bioclimatic comfort with minimal energy expenditure. Typical examples of these architectural compositions are, for example, the Olympic-sized gymnasium in the lagoon of the extremely seismic Argostoli city, or the equivalent in the lagoon of Lefcada city. In the swimming centre in Pallini, Attica, a large span roof was designed and constructed in a way that it can be opened at will, for its maximum bioclimatic function. In addition to large static spans and difficult environmental conditions, buildings were studied and built to protect other, more vulnerable, structures, such as the protective, glulam and steel, roof with a static span of over 40 meters, covering the, pre-existing reinforced concrete two-story ski centre at the top of Mount Parnassos. Special design of the load-bearing components of these structures was required, along with a parallel study of original methods of connection systems, as well as methods of erection without scaffolding and in the shortest possible time. All of the above, always, with the modern search for "smart" methods of bioclimatic comfort without excessive energy consumption. Load-bearing members made of glulam, steel, CLT, as well as composites load bearing systems, were designed according to the requirements of the Eurocodes. Close collaboration between the Architect, the Civil Engineer and the Mechanical Engineer was implemented from the preliminary design stage. The implementation of these projects, often following Architectural Competitions, has proven that Modern Structural Systems, with the use of New Building Materials and the application of advanced methods, both in design and construction, can be fully economically competitive with Conventional Construction. It also became apparent that there is a need for Technological Educational Institutions to closely monitor the rapid technological developments of European Structural Technology.

CS01 - Smart Systems & AI for Urban Efficiency

CASE25_CS_I_02 — Integrating External Environmental Sensors with Soil Biochemistry for Plant Growth Optimization in Precision Agriculture

Andreas Stylianou, Konstantinos Tatas[1]

[1] Department of Electrical Engineering, Computer Engineering and Informatics, Frederick University, Nicosia, Cyprus

Abstract.

Climate change, population growth, and urbanization pose critical challenges to food production, requiring the adoption of advanced technologies such as Artificial Intelligence (AI), automation, and the Internet of Things (IoT). These technologies support smart agriculture by enabling data-driven optimization of yields and more efficient resource use, especially water. While most smart farming systems focus on monitoring environmental parameters such as light, temperature, humidity, and CO_2, they rarely integrate these with internal soil biochemical signals. This study proposes a hybrid monitoring framework that combines external environmental conditions with in-soil plant hormone levels and microbial activity to optimize plant growth holistically. Two datasets were analysed: one representing environmental variables (e.g., sunlight, temperature, humidity, irrigation frequency), and another representing internal soil metrics (including hormone and enzyme activity). Although these datasets were independently generated, statistical normalization and crossmapping techniques were used to align them based on treatment context and observed growth outcomes. The integrated model revealed that while environmental metrics explain shortterm variance in growth, internal biochemical signals—such as Zeatin and FDH levels—offer longer-term predictive value for sustained biomass accumulation. This study demonstrates that combining both internal and external variables enhances the predictive accuracy of crop performance models. It advocates for a shift from surface-level monitoring to multi-layered sensor frameworks that capture the internal physiological state of plants, laying the groundwor.

CASE25_CS_I_05 — A Novel Adaptive Sampling Algorithm for Dependent Variables in Energy-Efficient IoT Sensor Nodes and its Application in Agriculture

Konstantinos Kosti[1] , Konstantinos Tatas[1], Eleni Tsolaki[2]

[1] Department of Electrical Engineering, Computer Engineering and Informatics, Frederick University, Nicosia, Cyprus

[2] Department of Maritime Transport and Commerce, Nicosia, Cyprus

Abstract.

Sensor nodes are an essential component in many smart applications. Adaptive sampling is a promising technique for minimizing energy consumption in power-constrained sensor nodes while simultaneously improving data quality by minimizing redundancy. Various schemes have been proposed in the literature but consider the variables to be sampled as independent and dependencies between them are commonly examined after sampling. In practice however, many applications involve parameters with various dependencies, as well as cases where the value of one parameter is used to calibrate or correct the other parameter, for example in temperature compensation. The paper proposes an innovative algorithm for adaptive sampling that takes into account the various kinds of dependencies between the variables. The algorithm employs a predictionbased scheme to determine whether the dependent variable is expected to remain within a predefined 'safe' range, which would result in the sampling rate for both variables to be decreased. Otherwise, the sampling rate for the dependent variable would be increased and if the variable is expected to be below a safety margin, the independent variable would also be sampled and the dependent variable value would be adjusted accordingly. The prediction scheme is also updated if the predicted values differ significantly from the observed values. The framework is verified using both generated and real data from agriculture. Evaluation metrics include, the ratio of the number of samples obtained over the number of samples required using constant sampling rate. Additionally, the sum of squared errors between predicted and actual values is used to assess prediction accuracy. Experimental results show that a significant portion of samples can be omitted, leading to substantial energy savings which translate to longer battery life for IoT nodes. The error incurred by the model is acceptable, especially when the application only requires monitoring of variables over an acceptable range.

CASE25_CS_I_07 — Green-HIT: An End-to-End IoT System for Forest Monitoring and Management

Andreas Pamboris[1]*; Iasonas Iasonos[1]; Nicolas Kyriakou[2]; Maria Prodromou[3]; Pericles Cheng[4]; Andreas Konstantinidis[1];

[1] Frederick Research Center, Nicosia, Cyprus

[2] Cy.R.I.C Cyprus Research and Innovation Center, Nicosia, Cyprus

[3] ERATOSTHENES Centre of Excellence

[4] European University Cyprus, Nicosia, Cyprus

*E-mail: res.ap@frederick.ac.cy

Abstract.

Forests play a critical role in climate regulation, biodiversity preservation, and ecosystem sustainability, making their protection and effective management a strategic priority under the European Green Deal. In this context, we present Green-HIT, a holistic Internet of Things (IoT) system designed to transform forest management and monitoring through the integration of advanced Information and Communication Technologies (ICT). The Green-HIT system addresses key challenges faced by forest authorities and environmental stakeholders by enabling real-time monitoring, intelligent decision-making, and automated response mechanisms. It incorporates a range of capabilities including prevention and early detection on, as well as reaction to forest fires, afforestation and reforestation planning, illegal activity detection (e.g., logging and hunting), and the generation of forest mapping and inventory reports, using both field and remote sensing data. By leveraging edge computing, AI-driven analytics, cutting-edge Unmanned Aerial Vehicle (UAV) technologies, and interoperable data infrastructure, Green-HIT supports proactive forest management strategies aligned with green transition goals. This paper will demonstrate the effectiveness and efficiency of the system through a series of controlled pilot deployments in selected forest areas across Cyprus.

CASE25_CS_I_08 — AGRILORA: A LoRaWAN-based system for efficient crop monitoring with radio frequency energy harvesting

Nicolas Kyriakou[1]; Antonis Hadjiantonis[1]; Kostas Kyriacou[2]; Andreas Konstantinidis[2];
[1] CyRIC, Cyprus Research & Innovation Center ltd
[2] Department of Electrical Engineering, Computer Engineering and Informatics Frederick University, Nicosia, Cyprus

Abstract.
This paper presents a part of the AGRILORA system which uses the LoRaWAN network protocol alongside IoT sensing devices and cloud platform functionalities to create a system that provides crop monitoring and management. The pilot site used to test the system is a vineyard in the Troodos area of Cyprus, the IoT devices are placed in the vineyard to monitor various environmental conditions, the data collected is stored and processed on a cloud platform, the platform also contains algorithms that detect danger periods for diseases such downy and powdery mildew. The user can view the data from an online browser, they are also alert when a potential high-risk period happens for each disease. Some of the devices deployed utilize supercapacitors for charge instead of the standard lithium battery as environmentally friendly alternatives. Charging is done using energy harvesting via radio frequency (RF) energy which is provided to each device by mounting the power transmitting device to a drone that travels around the pilot site to charge them, each device is set up with a receiver antenna that receives this frequency and converts it to power.

CASE25_CS_I_10 — Open-Source BlueOS for Controlling the SeaBot USV

Giorgos Demetriou[1]*; Giorgos Trimithiotis[1]; Stefanos Lazaridis[1]

[1] Electrical Engineering, Computer Engineering and Informatics, Frederick University, Lemesos, Cyprus

*E-mail: g.demetriou@frederick.ac.cy

Abstract.

This paper presents the design, implementation, and validation of an automated oil detection and sampling system integrated into the SeaBot unmanned surface vehicle (USV) within the IRSAI maritime surveillance framework. Effective detection of oil pollution in coastal waters remains challenging due to resource limitations and the transient nature of contamination events. Our system addresses these challenges through a specialized mechanism mounted on the SeaBot that automatically detects oil presence and collects water samples for further analysis. The detection apparatus incorporates fluorometric sensors for hydrocarbon identification and surface tension measurements to provide real-time pollution assessment with minimal false positives. The system operates aboard the SeaBot USV, which features three operational modes: remote operation via teleoperation, autonomous navigation to coordinates provided by IRSAI's aerial platform (SkyBot), and dynamic positioning for precision sampling. Field validation in Lemesos Bay, Cyprus, demonstrates the detection system's reliability in identifying oil contaminants under varying environmental conditions, with high correlation between in-situ readings and subsequent laboratory testing. This approach significantly enhances maritime surveillance capabilities by enabling automated detection and sample collection at potential pollution sites while minimizing human intervention. The system's modular design supports future sensor expansions and integration with broader maritime monitoring networks, positioning it as an effective tool for enhancing coastal pollution monitoring capabilities.

CS02 - IoT for Precision Agriculture & Environmental Monitoring

CASE25_CS_I_03 — Spillover Effect Correction with/out Partial Volume Correction in Postsurgical SPECT/CT Imaging

Elena Ttofi[1]*; Costas Kyriakou[1]; Theodoros Leontiou[2]; Yiannis Parpottas[2]*;
[1] Department of Electrical & Computer Engineering & Informatics, Frederick University, Nicosia 1036, Cyprus
[2] Department of Mechanical Engineering, Frederick University, Nicosia 1036, Cyprus
*E-mail: st016269@stud.frederick.ac.cy; yparpottas@frederick.ac.cy

Abstract.
SPECT imaging is crucial in the evaluation of differentiated thyroid cancer, particularly in post-thyroidectomy patients. Individualized dosimetry and, consequently, individualized therapy requires accurate volume calculation and uptake quantification. However, both are significantly affected by partial volume and spillover effects. While previous studies have investigated partial volume correction (PVC) and limited studies investigated the impact of spillover correction (SOC), the combined contribution of both corrections on small volumes within physical phantoms was not previously investigated. The objective of this study was to evaluate the individual and combined contribution of SOC and PVC in SPECT/CT imaging when assessing small volumes. For this purpose, I-123 and I-131 SPECT/CT images from a neck-thyroid phantom containing small remnants (0.5-10 mL) were utilized. Two custom-made MATLAB algorithms were applied to correct for SO and PV effects, respectively, and calculate the volumes and their uptake values. Four datasets were created with: (a) no corrections, (b) SOC, (c) PVC, and (d) both corrections. On average, for the smaller volumes (0.5-1.5 mL), the % differences between the calculated volumes and the actual volumes, when applying both corrections, were 5.6% and 6.1% for the I-123 and I-131 images, respectively. When applying only the SOC, the corresponding % differences were 11.6% for I-123 and 12.7% for I-131. On the other hand, the uptake values when applying both corrections resulted in a reduction of 87% for I-123 and 84% for I-131. Applying only the SOC reduced the corresponding uptake by 78% for I-123 and 80% for I-131. PVC alone improved the corresponding calculated volumes by 12% for I-123 and 10% for I-131, while it reduced the uptake by 23% for I-123 and 25% for I-131. PVC on SPECT images, with a 4.44-mm pixel size, is more reliable for volumes >2 mL. The extent of the spillover effect is more profound in I-131 than I-123 imaging due to the I-131 higher energy, its collimator type, septa perpetration and scattering. For such small volumes, it is recommended to apply both corrections for accurate calculations of volume and uptake.

CASE25_CS_I_04 — Energy-Aware Coverage Path Planning in Dynamic Environments Using Deep Predictive Models

Irene- Maria Tabakis[1]* , Konstantinos Tatas[2] and Minas Dasygenis[1]

[1] Department of Electrical and Computer Engineering, University of Western Macedonia, Kozani, Greece

[2] Department of Electrical Engineering, Computer Engineering and Informatics, Frederick University, Nicosia, Cyprus

Abstract.

Energy-Efficient Coverage Path Planning (CPP) in dynamic environments remains a key challenge for autonomous systems operating in realworld scenarios. This paper introduces the Energy-Aware Predictive Coverage (EAPC) framework, a hybrid approach that integrates Deep Reinforcement Learning (DRL) with predictive modelling to enable adaptive and sustainable navigation. EAPC incorporates Gated Recurrent Unit (GRU) to forecast the motion of dynamic obstacles, allowing the agent to proactively adjust its trajectory. These predictions are embedded into an augmented state vector alongside terrain and obstacle features. A multi-objective reward function penalizes energy-intensive actions, abrupt accelerations, and potential collisions, encouraging smoother, more efficient behaviors. The framework is evaluated in a simulated environment with procedurally generated terrain and moving obstacles. Comparisons with classical planners (A*, RRT) and modern RL methods (PPO, SAC) are made using metrics such as coverage, energy usage, collision rate, and adaptability. Results show that EAPC significantly improves both energy efficiency and robustness in dynamic settings. This work advances the development of intelligent, resilient, and energy-aware autonomous systems. Potential applications include precision agriculture, infrastructure monitoring, and post-disaster inspection, where energy-conscious autonomy is crucial.

CASE25_CS_I_06 — A Green Energy-Management Framework for Aggregator Participation in the Day-Ahead Market

Thalis Papakyriakou[1], Andreas Pamboris[1], Andreas Konstantinidis[1]
[1] Frederick Research Center, Nicosia, Cyprus

Abstract.
The efficient exploitation of renewable energy sources is crucial for addressing the global energy crisis and increase in CO2 emissions. Energy management system aggregators, functioning as cooperatives within energy communities, hoard renewable energy resources and profit from satisfying DSO energy flexibility requests, or they incentivize residents towards selfconsumption through dynamic pricing schemes, receiving subsidies as reward. This interaction between aggregator and residents is typically modeled using bi-level optimization frameworks, however, existing research studies often ignore the intersection between the profitability of aggregators and the pursuit of self-consumption within their communities. This work presents a bi-level multi-objective Green Energy-Management Framework (GEMF) for energy communities that maximizes the profitability of the aggregator at the upper level while simultaneously offering high levels of self-consumption, and maximizes the welfare of the residents at the lower level. Based on the energy consumption patterns of 10 UK households as recorded in the REFIT public dataset, our experimental evaluation has shown that GEMF achieves a higher-quality tradeoff between profitability and self-consumption compared to alternative approaches, while also achieving a high-quality trade-off between the conflicting objectives at the resident level.

CASE25_CS_I_12 — Multi-Stage Cascaded Algorithm for Localization with Integrated BEacon Ranking (CALIBER) for Bluetooth-Based Indoor Localization

Nikos Antoniou[2], Nicolas Kyriakou[2], Costas Kyriacou[1], Andreas Konstantinidis[1]
[1]Department of Electrical Eng., Computer Eng. and Informatics, Frederick University, Nicosia, Cyprus
[2] Electronics and Networks Division, R&D Department, CyRIC, Nicosia, Cyprus

Abstract.
Accurate indoor localization using Bluetooth Low Energy (BLE) remains challenging due to high variability and noise in Received Signal Strength Indicator (RSSI) measurements. This paper presents a multi-stage Cascaded Algorithm for Localization with Integrated BEacon Ranking (CALIBER) designed to enhance the accuracy of distance estimation and position inference in BLE-based systems. The proposed approach combines four successive processing stages: (1) beacon selection using a Minimum Composite Score criterion to filter unstable transmitters; (2) outlier removal through Median Absolute Deviation and Temporal Consistency Check; (3) residual noise reduction using Gaussian Kernel Smoothing; and (4) adaptive signal refinement via an Extended Kalman Filter. Filtered RSSI values are converted to distance estimates using a free-space path loss model, followed by trilateration to compute two-dimensional positions. Experimental evaluation in a corridor testbed demonstrates that the proposed CALIBER algorithm achieves a 56.9% improvement in localization accuracy compared to unfiltered RSSI input, reducing the mean localization error from 4.58 m to 1.97 m. Furthermore, by excluding extreme static points that exhibit uncharacteristic signal behavior, the mean error is further reduced to 1.12 m. The system requires only BLE beacons as infrastructure, making it easy to deploy and a low-cost solution for indoor localization in various built environments.

CASE25_CS_I_13 — FoodFlow-1.0: A Smart IoT System for Manual Food Waste Logging for Hotels

Markides Christos[1] , Pericleous Savvas[1], Achilleos Achilleas[1], Hamrouni Houssam[1]; Philippou Panagiotis[1]

[1] Department of Electrical and Computer Engineering and Informatics (DECEI), Frederick University, Nicosia, Cyprus

Abstract.

Food waste is an unquestionable problem in the Mediterranean hospitality sector, where buffet-style dining and seasonal tourism contribute to large volumes of discarded food. Although, this is often perceived as an unavoidable consequence of service, hotel managers are currently not able to quantify the problem, much less to act on it. This paper presents FoodFlow-1.0, a smart IoT system designed to tackle the problem of food waste management in hotel kitchens by enabling manual recording of food waste, at each stage of the process chain, thus empowering hotel chefs, managers, and owners to exploit the value of data. Via a structured food categorization process adapted to local hotel menus, kitchen staff track details of every food wasted. The system consists of an integrated hardware station, which includes an industrial-grade scale, a touchscreen, and a camera. The tablet software is connected to a cloud-based platform for submitting data and a web application enables data analytics and visualization. Despite strong initial staff resistance, the first contribution to build a strong dataset was achieved. Also, the intuitive food waste analytics dashboard convincingly revealed waste volumes and patterns, empowering evidence-based decisions that can foster sustainable kitchen operations and challenge rooted local attitudes toward food waste. By generating reliable data and enabling evidence-based decisions, it supports the second contribution that more sustainable kitchen operations contribute to changing long-standing cultural perceptions around food waste in the Med region.

CvE01 - Policy, Design & Innovation

CASE25_CvE_E_8 — Towards the enrichment of Construction VET courses for the Green and Digital Transition: The Buildskills Academy Paradigm

Antonia Christou[1]; Sara Mariza Vryonidi[1]; Irene Constantinou[1]; Elia Tantele[1]; Georgia Savva[1]; Lyubomir Peynovski[2]; Mariyana Hamanova[2]; Maria Nakova[2]; Stylianos Yiatros[1]

[1] Department of Civil Engineering and Geomatics, Cyprus University of Technology

[2] Cleantech Bulgaria Foundation

Abstract

The construction sector faces evolving skills needs as it undergoes twin digital and green transitions, yet vocational education and training (VET) programmes have been slow to integrate these emerging competencies. The Buildskills Academy via strong network of partners across Europe aims at the strategic development of Upskilling and Re-skilling of the construction ecosystem with certified transitional skills and competences. The BuildSkills Academy has responded to this challenge through the development of the BuildEnrichedSkills Methodology (BESM), a structured framework designed to enrich VET courses across EQF levels 3–7 (Buildskills Academy, 2024). BESM follows a three-stage cycle: (1) a digital self-assessment questionnaire aligned with EQAVET indicators, (2) a gap analysis against a matrix of green and digital skills developed for 38 construction occupations, and (3) enrichment guidance for course content and delivery. Key gaps identified across partner institutions include the limited integration of life cycle assessment, nature-based systems thinking, and digital risk modeling, particularly in higher-level curricula.

This article focuses on the enrichment process of two EQF level 6 courses as pilot applications of BESM. The first, Bio-inspired Innovation and Design for Sustainable Engineering, introduces learners to biomimetic thinking as a framework for systems innovation. It leverages challenge-based learning and tools such as the Copernicus Climate Atlas and life cycle assessment software to train learners in environmentally responsive design. Inspired by principles from Benyus (1997) and Baumeister (2014), this course enables civil and architectural engineers to emulate nature's adaptive strategies and design for climate resilience. The second course, Risk and Reliability in Health and Safety, targets the development of analytical skills to assess human error, structural uncertainty, and safety system reliability. Based on frameworks from Melchers & Beck (2018) and Dhillon (2013), this course applies human reliability analysis and risk matrices to simulate workplace scenarios. Together, these enriched courses demonstrate how BESM fosters future-proof skills and pedagogical transformation in construction education, as well as pave the way for the wider use of the methodology.

CASE25_CvE_I_01 — Reliability-Based Assessment of Eurocode 7 Design Practices Considering Soil Variability

Christakis Onisiphorou[1]; Panagiotis Christodoulou[1]*
[1] Department of Civil Engineering, Frederick University, Nicosia, Cyprus
[2] Department of Civil Engineering, Neapolis University, Pafos, Cyprus
*E-mail: eng.oc@frederick.ac.cy

Abstract. Natural hazards such as flooding and landslides can significantly alter the engineering properties and internal stress states of soils, consequently affecting the performance of foundations for structures. Therefore, risk assessment evaluation is important for shallow foundation analysis to ensure the stability and safety of a structure. In geotechnical design, the assessment of risk involves modelling the variability and uncertainty of soil properties, particularly accounting for changes induced by natural hazards. By integrating these changes into foundation design, engineers can develop more resilient and reliable structures. Conventional geotechnical design methods usually lead to a single factor of safety which does not adequately account for the variations of soil properties. In contrast, a risk assessment analysis provides a more meaningful evaluation by quantifying the probability of failure and the reliability index. This more advanced probabilistic method can provide a valuable tool for modelling soil variability and alterations in soil structure due to natural hazards, and therefore it can contribute for a more sustainable design. The current work investigates the performance of shallow foundations on clays by considering the effects of natural hazards on the statistical distribution and stress conditions of soils. This investigation was conducted by applying the three different design approaches, as proposed by Eurocode 7, in terms of a risk and reliability analysis. The undrained shear strength was introduced in the form of a random field variable and multiple Monte Carlo simulations were performed, with its statistical properties adjusted to represent conditions both before and after hazard events. The results are presented and compared using a reliability index to examine the effect of soil variability among the different design practices of Eurocode 7.

CASE25_CvE_I_02 — Simulation of Temperature Evolution and Stress Development in Hardening Concrete

Antonis Michael[1]; Demetris Nicolaides[1]

[1] Department of Civil Engineering, Frederick University, Nicosia, Cyprus

Abstract.

In previous centuries, the main and most popular building material in Cyprus was the calcarenite stone (also called “pouropetra”). This natural stone was used to construct both exterior and interior walls and floors in all types of buildings (residences, mansions, churches, public buildings, etc.), as it is durable and weather resistant. Due to unique architecture, these buildings are classified as listed and their repair and restoration require the use of natural calcarenite stone. However, the construction industry faces serious difficulties in sourcing this material, since the Turkish invasion and occupation of Cyprus in 1974, as the only operating calcarenite stone quarry is located in the occupied area of the island. As a result, the restoration of these buildings is progressing extremely slowly, although their use is an immediate necessity, due to the growing urban population. This paper presents the preliminary results of a research aimed at developing a synthetic calcarenite stone with the same texture and similar properties to the natural one, in order to be used for the restoration of the traditional cultural heritage buildings in Cyprus. The synthetic stone is based on gepolymerization, utilizing the waste mud from a local quarry of calcarenite aggregates as raw material. Geopolymerization is a low energy and reduced carbon emissions technology that achieves to transform a wide range of industrial wastes into value-added products with unique properties. In this paper, the waste calcarenite mud is characterized and evaluated as a precursor source for geopolymerization. Moreover, the effect of basic geopolymerization parameters on critical properties of the synthetic stone, such as porosity, water absorption, acid resistance and mechanical strength, is investigated. According to the results, the development of synthetic calcarenite stone is feasible and could be a viable solution for the repair and restoration of traditional listed buildings in Cyprus.

CASE25_CvE_I_06 — Towards a Harmonized Building Legislation Framework in the European Union: Challenges and Prospects

Marios Panagides[1]; Petros Christou[1]
[1]Department of Civil Engineering, Frederick University, Nicosia, Cyprus

Abstract

The regulation of construction and building activities in the European Union remains characterized by considerable fragmentation, with each member state maintaining distinct building codes and regulatory systems. This divergence presents substantial obstacles to the functioning of the internal market, creates inefficiencies for businesses, and complicates the pursuit of sustainability and safety objectives. This paper provides a comprehensive assessment of the legal, political, economic, and technical challenges inherent in harmonizing building legislation across the EU. It critically evaluates national sovereignty issues, the subsidiarity principle, and resistance from industry stakeholders as key impediments. Moreover, it examines the economic costs and safety risks linked to regulatory fragmentation. Building upon this analysis, the paper proposes a hybrid harmonization model featuring EU-wide minimum standards complemented by national discretion. The role of digital tools, particularly Building Information Modelling, is discussed as a catalyst for integration. The study concludes that while complex, harmonization of building legislation is essential for enhancing the EU's competitiveness, fostering sustainable construction practices, and supporting internal market cohesion.

Keywords: building legislation, harmonization, European Union, construction regulation, regulatory fragmentation, internal market, subsidiarity principle, cross-border construction, construction sector competitiveness, sustainability, Building Information Modeling (BIM), regulatory convergence, construction safety, energy performance

CASE25_CvE_I_07 — The Role of Building Legislation in European Economic Integration: Analyzing the Path to Standardization

Marios Panagides[1]; Petros Christou[1]
[1]Department of Civil Engineering, Frederick University, Nicosia, Cyprus

Abstract

The construction sector is undeniably foundational to the European Union's economy, underpinning growth, employment, and urban development. Yet, despite its vital role, the sector remains fragmented by a patchwork of divergent national building regulations, which hamper efficiency, increase costs, and complicate cross-border operations. This study offers a comprehensive examination of the regulatory frameworks governing building legislation across all 27 EU member states. Utilizing a mixed-methods approach, including comparative legal analysis, expert interviews, and economic modelling, it unravels both the common threads and stark divergences shaping the sector. The findings illuminate the significant challenges posed by disparate legal traditions, enforcement mechanisms, and compliance norms. Nonetheless, the paper outlines a pragmatic, phased roadmap toward harmonization that respects subsidiarity while fostering greater regulatory convergence. Such standardization promises to not only streamline construction processes but also to strengthen investor confidence, enhance safety, and propel the EU closer to a fully integrated Single Market in construction services. The study concludes with actionable policy recommendations aimed at navigating the complex interplay between national autonomy and collective European interests.

Keywords: Building Legislation, European Union, Regulatory Standardization, Construction Policy, Economic Integration.

CvE02 - Environmental Resilience & Climate Risk

CASE25_CvE_E_4 — Experimental Investigation and Nonlinear Finite Element Analysis of Corroded Reinforced Concrete Elements Retrofitted with Strain-Hardening Cementitious Composites (SHCCs) and Fiber-Reinforced Polymers (FRPs)

Nikolaos Tzavellos[1], Christos Petrides[1], Salomi Papamichael[1], Natia R. Anastasi[1], Aikaterini S. Genikomsou[2] , Anthos I. Ioannou[1]

[1] Department of Civil Engineering, Neapolis University Pafos, Danaıs 2, 8042 Pafos, Cyprus

[2] Department of Civil Engineering, Queen's University, 58 University Avenue, Kingston, K7L 3N6, Ontario, Canada.

Abstract. Corrosion-induced deterioration of reinforced concrete (RC) structures remains a major concern in structural engineering, especially in coastal or chloride-rich environments. This study investigates the structural performance of corroded RC elements strengthened with Strain-Hardening Cementitious Composites (SHCCs) and FiberReinforced Polymers (FRPs) using a combined experimental and numerical approach. RC specimens are subjected to accelerated corrosion via the impressed current technique, then retrofitted either with SHCC overlays or externally bonded FRPs. The experimental phase, currently in progress, includes flexural tests to evaluate the retrofits in terms of load-bearing capacity, ductility, and failure mechanisms. Image-based deformation measurements complement these tests, providing data for the validation of advanced nonlinear finite element models developed in ABAQUS. These models incorporate both corrosion-induced material degradation and the complex behaviour of the retrofitted systems under monotonic loading. The main objectives are to: (i) quantify the mechanical degradation caused by corrosion, (ii) compare the effectiveness of SHCC and FRP retrofits, (iii) assess the predictive accuracy of finite element models in capturing nonlinear response, and (iv) identify effective strategies for modelling corrosion in RC members. The findings aim to inform the design of durable and efficient retrofitting solutions, improving the resilience of aging infrastructure exposed to aggressive environments.

CASE25_CvE_E_5 — Passive House Apartment building in hot climate. Example of energy neutral low cost building

Milos Ilic[1]*
[1]Passive House Development ltd, Nicosia, Cyprus

Abstract
Passive House Latsia is the first apartment building in Cyprus to be designed according to the Passive House Standard and is set to be certified by both the Hellenic Passive House Institute and the German Passive House Institute. The building comprises 30 apartments with a total area of 2,800 m^2 and is part of the government's "Ktizo" initiative for social and affordable housing aimed at young families. Currently under construction, the project is scheduled for completion by the end of 2025. It serves as a prime example that high thermal comfort and ultralow energy demand can be achieved in cost-effective housing. With just a 40 kW photovoltaic system, the building will be energy-neutral—generating as much electricity as it consumes.

CASE25_CvE_I_09 — Analysis of Climate Change Indicators in Troodos Mountain Geopark, Cyprus: Quantitative and Qualitative Perspectives

Georgios Xekalakis [2], Christos Anastasiou[1], Petros Christou[1]
[1] Department of Civil Engineering, Frederick University, 1036 Nicosia, Cyprus
[2] Frederick Research Center, 1036 Nicosia, Cyprus

Abstract.
This study presents an integrated assessment of climate change indicators within the Troodos Mountain Geopark in Cyprus, combining long-term climatic datasets with hydrochemical and ecological analyses. Quantitative methods are used to evaluate key parameters— temperature trends, precipitation variability, extended dry spells, and wildfire frequency—while qualitative assessments capture associated shifts in biodiversity, forest ecosystem health, and hydrological conditions. The findings reveal significant warming, declining precipitation, and more frequent dry periods, all signaling increased environmental stress in the region. Groundwater remains chemically stable, though vegetation degradation and elevated fire risk point to growing ecological vulnerability. These shifts directly threaten the ecosystem services provided by the Geopark, including carbon sequestration, soil stabilization, and biodiversity maintenance. The study emphasizes the importance of integrating government-sourced climate data with ecosystem service mapping to inform targeted adaptation measures. In alignment with the objectives of the ClimEMPOWER project, this research offers valuable insights for policymakers, scientists, and stakeholders aiming to build climate resilience in Cyprus's mountain environments.

CASE25_CvE_I_11 — Explosions and transmission of blasting waves: Validation of numerical simulations

George Piperides[1], Milton Demosthenous[1]*
[1] Civil Engineering Department, Frederick University, Nicosia, Cyprus
*E-mail: eng.dm@frederick.ac.cy

Abstract.

The heavy industrial infrastructures, such as power plants, oil gas facilities e.t.c., have an important role on the sustainability of a country, strongly depended by the resilience and the low risk of these infrastructures during operation. The explosions and the effects of the created blasting waves is one of the main risk parameter and case of losses of the structures and the human life. After the 2nd world war many research efforts and international standards were established to assess and protect the human activities by the explosions and blasting waves. The theoretical background and the used analytical equations for that have many constraints and limitations because they refer to simple and not complicated cases, ignoring the topography, the spatial transmission and the reflection of blasting waves in sometimes, e.t.c. For that, the last years, few sophisticated software were developed which can be used in practice, based on numerical simulations of such problems and at the same time taking in the account a lot of parameters related to the real problem. However, due to the complicity of the real situations, these software are under a continuity upgrading and revising. Therefore, they must be checked before any use.

This paper deals with the validation of the numerical simulations of such software through various parametric investigations. The present effort focus on simple problems and the results from numerical simulations are compared with those given by the analytical solutions. The influence of the dimensions of the numerical cells to the numerical results as well the absorption of the blasting waves as is transmitted far from the location of the explosion is studied and discussed. In addition to that, the risk-levels as are defined by international standards and other guidelines are compared with the corresponding results from the numerical simulations.

CASE25_CvE_I_12 — Concrete Sections Reinforced with FRP Bars and Grid: A sustainable Alternative for Highly Corrosive Environments?

Antonis Michael[1]*; Demetris Nicolaides[1]; Christos Anastasiou[1]

[1] Department of Civil Engineering, Frederick University, Nicosia, Cyprus

*E-mail: eng.ma@frederick.ac.cy

Abstract.

Structures in highly corrosive environments (bridges crossing sea waters, marinas or ports) have traditionally used typical reinforced concrete or pre-stressed concrete sections. This has several problems since the steel reinforcement is quickly starting to corrode needing constant monitoring and maintenance or protection of the reinforcement which is quite expensive. Cathodic protection is one initial measure used to delay reinforcement corrosion but usually this does not have the long-term effect desired with more measures necessary such as external jacketing. Unfortunately, the employment of these measures does not prolong the service life of the structure to the design levels initially intended which are typically more than 75 years. Instead, replacement of the structure is mandatory after as soon as 30 years due to extensive damage and strength issues associated with the damage. If a new alternative that is immune to corrosion and with a service life far longer than the one associated with the traditional concrete is found, then this can lead to potentially a sustainable option with not only financial sustainability but also to lower carbon footprint and less use of resources. Such an option can be the replacement of steel reinforcement with FRP reinforcement. This combined with a new design approach (compression-controlled design and concrete confinement) can offer a viable structural alternative that can overcome the shortcomings of traditional reinforced concrete. Studies have shown that this replacement can have a reduction in carbon footprint as high as 25% considering the construction face. To assess the structural suitability of the new alternative several cast-in-place (CIP) concrete pile specimens reinforced with FRP bars and CFRP grid were tested in flexure. Four cast-in-place specimens were evaluated. Some of the specimens had no grid and served as control or reference piles. The higher strength and ductility factors of the specimens reinforced with the CFRP grid show that the development of structural members to replace traditional ones is possible. The experimental ductility factors of the specimens reinforced with the CFRP grid were as high as 1.73 times the ductility factors of the control specimens depending on the factor used (deflection of curvature). Resistance improvement was also observed with an increase as high as 58% recorded.

CASE25_CvE_I_13 — Risk and reliability analysis of gravity wall seismic performance for sustainable slope stability

Christakis Onisiphorou[1]*
[1] Department of Civil Engineering, Frederick University, Nicosia, Cyprus
*E-mail: eng.oc@frederick.ac.cy

Abstract.
Climate change affects significantly the stability of soil slopes towards landslides especially when intense and continuous rainfall occurs. Though it is aimed currently to use sustainable solutions for stability with mild or no intervention on a natural slope, it is sometimes necessary to implement retaining walls for both slope protection and keeping roads clean from falling rocks and soil debris. Gravity walls provided an early form of such walls, while with time these were replaced by reinforced concrete walls taking less space. However, with the progress on concreting techniques, construction methods and modern precast materials, gravity walls are very much still used as they hold their own advantages, especially when there is lack of working space or in mountainous regions on roadsides. The current paper considers the performance of such gravity retaining walls using a risk and reliability analysis to model the uncertainty of soil conditions behind the wall. This type of analysis is important for ensuring the stability and safety of the wall and retained slope, as it leads to a probability of failure and a reliability index, instead of a single, overall factor of safety. Soil shear strength properties and the horizontal seismic coefficient were modelled as random variables and various values of mean and variance were investigated to assess its performance under seismic loading, using a pseudo-static analysis. In addition, the total number of realizations run by Monte Carlo simulations was assessed for an optimum solution.

CvE03 - Sustainable Construction & Materials

CASE25_CvE_E_3 — Optimisation of Synthesis Conditions and Investigation of Durability and Transport Properties of High Temperature Performance Geopolymer Coating for Substrates

Ponsian M. Robert[1]*, Nicolas Gay[1]

[1] Univ. Lille, CNRS, Centrale Lille, UMR 9013 – LaMcube – Laboratoire de Mécanique, Multiphysique, Multiechelle, F-59000 Lille, France

*E-mail: ponsian.robert@centralelille.fr

Abstract.

This study investigates the formulation and durability of fire-resistant intumescent geopolymer (IG) as a substrate, focusing on its transport properties. The IG was developed using metakaolin and silica fume as precursors, activated by a 7M NaOH alkaline solution and a potassium-based silicate solution (molar ratio: 1.7). The precursor-to-activator ratio was 2.8, with NaOH-to-K-silicate at 0.48. Various metakaolin-to-silica fume ratios (100:0, 90:10, 70:30, 50:50) were tested. The 70:30 mix achieved the highest compressive strength (25.2 MPa) but the minimum flexural strength (4.4 MPa). Adding 2 wt.% H_2O_2 reduced compressive strength to 5.5 MPa while increasing flexural strength to 14.3 MPa, attributed to increased cross-linking from oxygen release.

Thermal analysis showed that the optimized intumescent geopolymer (IG) exhibited excellent fire resistance, maintaining structural integrity without cracks or disintegration at temperatures up to 1050 °C. However, it experienced an average mass loss of 23% between 600 °C and 1050 °C. Dry shrinkage was recorded at −1.9% at 600 °C, −3.01% at 800 °C, and 10% at 1050 °C. Further durability tests will assess heat flow rate, oxygen permeability, mass transfer, and diffusion. These results will highlight IG's potential for high-temperature applications, offering enhanced fire resistance with customizable mechanical properties.

CASE25_CvE_E_6 — Main factors that influence alkali activation of slag produced after pyrometallurgical treatment of laterites

Kostas Komnitsas[1]*, Vasiliki Karmali[1], Dimitra Vathi[1], and Georgios Bartzas[1]

[1] School of Mineral Resources Engineering, Technical University of Crete, 73100 Chania, Greece

*E-mail: kkomnitsas@tuc.gr

Abstract.

The present study investigates the potential of alkali activation of slag produced after pyrometallurgical treatment of laterites for the production of ferronickel (FeNi) at Kavadarci, Republic of N. Macedonia The effect of the main factors including molarity (M) and SiO2/Na2O molar ratio in the activating solution, pre-curing (6 to 96 hours) and curing time, curing temperature (20 to 80 oC) and aging period (7 τo 90 days) on the main mechanical and physical properties of the produced alkali activated materials (AAMs) is assessed. Also, in order to evaluate the structural integrity of the AAMs selected specimens were (i) fired at 400, 750 and 1000°C, (ii) immersed in distilled water and 1M HCl solution and (ii) subjected to freeze-thaw cycles involving temperatures of -18 ± 5 °C for 4 hours and room temperature (20 ± 0.5 °C). The leaching of potentially hazardous elements (PHEs) from slag and selected AAMs was evaluated with the use of EN 12457-2 test. Several analytical techniques including X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FTIR) and Scanning electron microscopy (SEM) are used for the identification of the mineralogy and the morphology of the precursor and the final products. The experimental results indicate that the produced AAMs in the optimum experimental conditions achieve a compressive strength that exceeds 40 MPa after an aging period of 7 days; if the aging period becomes 28 days the compressive strength exceeds 70 MPa. The produced AAMs maintain their structural integrity when immersed in distilled water, whereas a minor loss in strength is recorded, that does not exceed 10%, after immersion in HCl solution or subjection in freeze-thaw cycles,. However, major disintegration is noticed after heating of AAMs above 750 oC. Finally, both the slag and the produced AAMS exhibit very low toxicity.

CASE25_CvE_E_7 — Contribution of alkali activation towards zero-waste management, low-carbon cities and sustainable development

Konstantinos Komnitsas[1]*

[1] School of Mineral Resources Engineering, Technical University of Crete, 73100 Chania, Greece

*E-mail: kkomnitsas@tuc.gr

Abstract. Buildings are responsible for around 37 % of energy and process-related CO2 emissions and over 34 % of energy demand. At European Union (EU) level 85% of the buildings were built before 2000 and amongst those, 75% have a poor energy performance. Thus, the EU with its Energy Performance of Buildings Directive (EU/2024/1275) and the revised (EU/2023/1791) aims to reduce GHG emissions by at least 60% in the building sector by 2030 compared to 2015, and achieve a decarbonised, zero-emission building stock by 2050. Portland cement is the main ingredient of concrete. It is manufactured from various materials, e.g limestone, marl and clay, that are heated at high temperature, 1450 oC, to form a rock-like substance that is ground into a fine powder. This energy intensive process releases approximately 0.90 tons of CO2 per ton of clinker. The last years intense efforts are made to utilise industrial wastes, such as fly ash from thermal power plants and various slags from the steel and non-ferrous metallurgical industry, for the production of binders that can replace cement and reduce CO2 emissions by almost 70%. These new binders are called geopolymers or alkali activated materials and can be produced from the reaction of aluminosilicate wastes with alkaline solutions at relatively low temperature, varying from 20 to 90 oC. The main benefits of alkali activation of wastes include reduction of CO2 emissions and prevention of major environmental impacts at waste disposal sites. The present paper investigates the waste types that can be alkali activated, the main factors that affect alkali activation, the tests that may be used to assess the toxicity of the wastes and the produced binders and the anticipated benefits for the construction sector and sustainable development.

CASE25_CvE_I_03 — Optimized Recycled Aggregate Concrete (RAC) formulations for Concrete Armor Units (CAU)

Christos Karapedis[1]*, Thomaida Polydorou[1], Konstantina Oikonomopoulou[1], Maria Georgiades[1], Dimitris Stagonas[1], Demetris Nicolaides[2,3] and Michael F. Petrou[1]
[1]Department of Civil and Environmental Engineering, University of Cyprus, Nicosia, Cyprus
[2]Department of Civil Engineering, Frederick University, Nicosia, Cyprus
[3]Frederick Research Centre, Nicosia, Cyprus
*E-mail: ckarap01@ucy.ac.cy

Abstract.
In the next years, the government of Cyprus is planning to construct a series of breakwaters along the island's coast and several marine infrastructure projects. Limestone, the only locally available natural rock that is suitable as the armor layer in such breakwaters, is currently facing reserve depletion, particularly in certain areas such as the Paphos district. This issue has created the need to expand quarrying activities into new regions, which may negatively affect ecologically significant areas and undermine the Republic of Cyprus' sustainability goals for preserving its natural resources and the environment. Instead, we could replace limestone rock armoring with Concrete Armor Units (CAUs), incorporating aggregates from various sources, including Recycled Concrete Aggregate (RCA). It should be noted that since no steel reinforcement is necessary for CAUs, there will be no concerns for corrosion. The use of RCA in CAU aligns with the EU Sustainable Development Goals and provides a large volume application where waste concrete can be successfully, significantly contributing to promoting sustainability. This study explores the feasibility of using RCA as partial or entire replacement of aggregates in optimized Recycled Aggregate Concrete (RAC) mix formulations for CAUs.

CASE25_CvE_I_04 — Comparative life cycle assessment of cement production in Cyprus: Insights from regional and global benchmarks

Maria Georgiades[1]*, Thomaida Polydorou[1], Demetris Nicolaides[2], Michael F. Petrou[1]
[1] Department of Civil and Environmental Engineering, University of Cyprus, 1678 Nicosia, Cyprus
[2] School of Engineering, Department of Civil Engineering, Frederick University, 1036 Nicosia, Cyprus
*Corresponding author. E-mail: georgiades.maria@ucy.ac.cy

Abstract

The rapid growth of industrialisation and urbanisation has significantly increased the demand for construction materials such as concrete, and consequently, for Porland cement. However, in regions like Europe, where ambitious climate targets have been established, the cement industry is under increasing pressure to decarbonise while continuing to meet the rising demand. Although a wide range of decarbonisation strategies have been explored in the literature, their adoption remains challenging in isolated or geographically constrained regions. This study presents a preliminary life cycle assessment (LCA) of cement production in isolated and remote regions, to evaluate environmental impacts in comparison with European and global benchmarks. The system boundary is defined as "cradle-to-gate," including raw material extraction, transportation, and manufacturing stages. The functional units considered are 1 tonne of clinker and 1 tonne of cement. The LCA was conducted using Activity Browser v2.8, with environmental impacts assessed using the ReCiPe (H) 2016 method. This analysis aims to identify key environmental hotspots in the cement supply chain under regional constraints. In particular, we seek to explore practical, regionally appropriate solutions that account for local resource availability and infrastructural limitations, promoting a more resilient and self-sufficient supply chain that can meet national demands while aligning with broader climate goals.

Keywords: Life cycle assessment, clinker, cement production, isolated and remote regions

CASE25_CvE_I_05 — Evaluation of Self-Compacting Concrete Incorporating Industrial Waste

Konstantina Oikonomopoulou[1]*, Thomaida Polydorou[1], Pericles Savva[2], Maria Georgiades[1], Christos Karapedis[1], Demetris Nicolaides[3,4] and Michael F. Petrou[1]
[1]Department of Civil and Environmental Engineering, University of Cyprus, Nicosia, Cyprus
[2]Latomia Pharmakas, Nicosia, Cyprus
[3]Department of Civil Engineering, Frederick University, Nicosia, Cyprus
[4] Frederick Research Centre, Frederick University, Nicosia, Cyprus
*E-mail: oikonomopoulou.konstantina@ucy.ac.cy

Abstract.
The utilization of recycled concrete aggregates (RCA) as a replacement for natural aggregates in concrete has been proven to improve sustainability performance and reduce environmental impact. However, incorporation of RCA into self-compacting concrete (SCC) mixtures yields challenges due to the sensitive nature of SCC and the reduction in overall performance caused by the RCA's attached mortar. Therefore, the application of a mechanical treatment method (for the partial removal of the adhered mortar), which has been proven sufficient to improve recycled aggregate concrete (RAC) performance, will be examined on SCC formulations. This article builds upon the author's previous research on the application of SCC produced using local materials and industrial by-products, specifically replacing limestone filler with limestone powder. The research program involved a series of small-scale SCC-RAC mixtures, designed to determine the optimum maximum percentage and grade of RCA to be included by a two-stage evaluation process: achieving rheological property targets (Slump Flow, V-Funnel, L-Box, Segregation Resistance) and demonstrating the overall best mechanical and durability performance. The maximum permissible percentage of RCA replacement in SCC-RAC combinations was determined based on the constituent analysis of aggregates and limitations set by European standards. Numerous laboratory-scale SCC-RAC formulations were cast and the optimum combinations for untreated and treated recycled concrete aggregates (RFC and RTC, respectively) were selected for large-scale evaluation. Three concrete slabs of 5 m3 (5.0 m x 5.0 m x 0.2 m) were cast: a non-RCA slab, an RFC slab and an RTC slab. Rheological characteristics were evaluated, and cylinders were extracted from the slabs after curing to assess the overall hardened concrete performance.

CASE25_CvE_I_08 — Valorization of Waste Diabase Mud from Aggregate Washing for the Development of Value-Added Building Materials

Maria Spanou[1,2]*, Ioanna Giannopoulou[1], Demetris Nicolaides[1]
[1] Frederick University, Cyprus
[2] Frederick Research Center, Cyprus
*E-mail: res.mas@frederick.ac.cy

Abstract.
Geopolymerization has emerged as a promising technology for producing sustainable and environmentally friendly construction materials by utilizing various industrial byproducts and waste materials. This study investigates the utilization of the waste diabase mud generated during aggregate washing in Cypriot quarries as a key raw material for the development of geopolymer building materials. Research has focused on the inϐluence of critical alkali activation parameters, such as sodium hydroxide (NaOH) concentration, sodium silicate (Na_2SiO_3) to sodium hydroxide ratio, and curing temperature and time, on the mechanical properties of the resulting geopolymers. Findings show that optimal compressive strength and durability are achieved under controlled curing conditions, when using sodium hydroxide concentrations between 8 M and 10 M. Further enhancement of the geopolymer matrix was explored through the incorporation of ground granulated blast furnace slag and metakaolin, which led to improved mechanical properties and increased sustainability. This work underscores the environmental beneϐits of reusing the waste diabase mud in the production of construction and building materials, contributing to industrial waste reduction and lowering carbon emissions compared to conventional Portland cement-products. The results support the broader implementation of geopolymer technology in sustainable construction practices

EE01 - Power & Control

CASE25_EE_I_01 — Harnessing Wind Energy From Highway Traffic To Power Led Directional Lighting Systems

Alexis Polycarpou[1]*; Komitis Andreas[1]
[1]Department of Electrical Engineering, Computer Engineering and informatics, Frederick University. Nicosia, Cyprus.
*E-mail: eng.pa@frederick.ac.cy

Abstract. Low-consumption LED light strips, positioned along the shoulder of the highway could serve not only to illuminate the roadway but also to indicate direction and improve visibility during nighttime driving conditions. The target is to provide a cost-effective, environmentally friendly lighting solution that reduces dependence on traditional grid electricity, especially in remote or poorly connected areas.

This Paper presents a theoretical investigation into the feasibility of utilizing wind energy generated by vehicular traffic on highways to power LED directional lighting systems. The concept leverages the airflow created by moving vehicles, which is typically unutilized, and proposes a method to capture this energy using compact vertical-axis wind turbines (VAWTs), particularly Savonius-type designs. These turbines are well-suited for turbulent, low-speed, and multidirectional wind flows—conditions often found near highways due to varying traffic speeds and vehicle types. The investigation remains theoretical but is rooted in real-world measurements of wind speed and traffic density collected along a major highway. The findings support the viability of implementing renewable micro-generation solutions for highway lighting, especially in regions like Cyprus, where energy independence and cost reduction are key priorities. By transforming wasted kinetic energy into useful electrical power, the system contributes to broader sustainability goals and paves the way for future advancements in decentralized, clean energy technologies.

CASE25_EE_I_04 — Adaptive Controllers for CCAM Applications in the presence of RIS assisted Collective Perception

Ehizogie I. Emoyon-Iredia[2,3], Shabab Saleem[2,3], Suleman Munawar[1,2], Nikolaos Ntetsikas[2,3], Rimsha Saeed[1,2], Chrysostomos Chrysostomou[2,3], Marios Lestas[2,3]
[1]National University of Sciences and Technology, Islamabad, Pakistan
[2]Frederick Research Center, Nicosia, Cyprus
[3]Frederick University, Nicosia, Cyprus
E-mail[1]: {smunawar.msee23aas, rsaeed.msee21rscs}@student.muet.edu.pk
E-mail[2,3]: {st015229, st023242}@stud.frederick.ac.cy, {res.as, ch.chrysostomou, eng.le}@frederick.ac.cy

Abstract.
Cooperative, Connected, and Automated Mobility (CCAM) is increasingly dependent on fast, secure, and reliable Vehicle-to-Everything (V2X) communication as well Artificial Intelligence (AI) techniques to enable collective perception and maneuver coordination in autonomous driving. Despite intense research, two problems still challenge wide scale deployment: uncertainties mainly emanating from leveraging AI methodologies; and highfrequency wireless communications, particularly in the millimeter wave (mmWave) and terahertz (THz) bands, which are highly susceptible to environmental obstacles, leading to severe signal attenuation and communication delays. To mitigate the latter RIS (Reconfigurable Intelligent Surface) technology has recently received significant attention. However, the effect of RIS on collective perception and automated control maneuvers has been scarcely researched in literature. In this work we report on the development of a simulator which allows integration of RIS technology with CPM exchange for CCAM applications enabling the characterization of uncertainties and communication delays demonstrating the performance gains as a result of RIS integration. Moreover, the adversarial effects of the uncertainties and delays on the performance of the cooperative control schemes are demonstrated using a platoon merging maneuver example as our test case. The results highlight the need for adaptive controllers which take into consideration the observed uncertainties and the delays. The pursued analysis formalizes the intuitive approach of increasing the inter-vehicle spacing as well as decreasing the speed of response in case of increased uncertainties and delays. Simulations results demonstrate the effectiveness of the presented approach.

CASE25_EE_I_05 — Towards a general Machine Learning model for energy profile predictions in Smart Energy Communities in Cyprus

Muhammad Ahmed Qureshi[1,2], Nicholas Christofides[1,2], Theodoros Leontiou[2], Haris Haralambous[2], Marios Lestas[1,2]*

[1]Frederick Research Center, Nicosia, Cyprus

[2]Department of Electrical and Computer Engineering and Informatics, Frederick University, Nicosia, Cyprus

*E-mail: eng_inf@frederick.ac.cy

Abstract

Algorithms developed for energy management systems in smart energy communities require accurate forecasting of the energy production from RES and load consumption profiles. The formulation and optimization of such algorithms may be multi objective aiming for example to maximize revenue from excess renewable energy or minimize the energy imported from the grid. This paper presents an approach to predict energy profiles using Long Short-Term Memory (LSTM) based neural network models for a community in Nicosia, Cyprus. The study addresses two key forecasting tasks: predicting photovoltaic (PV) energy production and estimating load demand for individual prosumers or consumers. For PV production forecasting, the model incorporates weather parameters such as solar irradiance, ambient temperature, and humidity, along with PV system capacities and geographical locations. For load forecasting, the model is trained on historical consumption patterns across multiple users. The models' performances are evaluated using Mean Squared Error (MSE), Root Mean Squared Error (RMSE), Mean Absolute Error (MAE), and Mean Absolute Percentage Error (MAPE). Results demonstrate that both LSTM models yield accurate and reliable forecasts suitable for effective energy management in smart communities.

CASE25_EE_I_06 — The Synergistic Role of Aggregators and Grid Suppliers within Energy Communities: The case of Cyprus

Kypros Tillyros[1,2], Shabab Saleem[1,2], Michael Kondrodomos[1,2], Nicholas Christofides[1,2]
[1]Frederick Research Center, Nicosia, Cyprus
[2]Frederick University, Nicosia, Cyprus
E-mail:
st023519@stud.frederick.ac.cy,st020691@stud.frederick.ac.cy,m.kondrodomos@frederick.ac.cy, n.christofides@frederick.ac.cy

Abstract.
The integration of renewable energy sources (RES) into the power grid has gained significant momentum as part of the global transition toward sustainable energy. However, the intermittent nature of RES, coupled with the constraints of existing grid infrastructure, often leads to energy curtailment, where surplus renewable energy cannot be utilised or stored. Energy Communities (EC) have emerged as a promising solution to address this challenge by promoting local energy production, consumption, and storage as well as efficient aggregation. Aggregators are new entries in the electricity market that will act as third-party entities in an attempt to balance supply and demand through Energy Communities. Given that EC enable collective energy management, fostering collaboration among prosumers, consumers, and local distribution networks, aggregators are expected to play a pivotal role by consolidating the energy resources of the community, optimising energy flow, and facilitating participation in electricity markets. On the other hand, grid suppliers ensure the reliable distribution of electricity while maintaining grid stability. This research looks into the impact of integrating battery storage systems within Energy Communities. If surplus energy can be efficiently stored and redistributed during periods of low generation or high demand, this approach significantly minimises the risk of energy curtailment and enhances the economic viability of renewable installations. As a result, this study presents a comprehensive analysis of how Energy Communities, guided by aggregators and supported by grid suppliers, can effectively reduce RES curtailment through strategic energy storage. The findings of this research highlight the critical role of Energy Communities in advancing the sustainable integration of renewable energy into the power grid while promoting a more resilient and decentralised energy landscape.

.

CASE25_EE_I_11 — Lithium-Ion Battery Simulation with complex 3D porous structures

A. Papadakis[1,2]*, V. Hadjigeorgiou[2]*
[1]Department of Electrical, Computer Engineering and Informatics, Frederick University, Nicosia, 1036, Palouriotissa, Cyprus
[2]KYAMOS LTD, 37 Polyneikis Street, Strovolos, Nicosia 2047, Cyprus
*E-mail: a.papadakis@frederick.ac.cy, apapadakis@kyamosmultiphysics.com
*E-mail: vhadjigeorgiou@kyamosmultiphysics.com

Abstract. This study presents an advanced simulation framework for lithium-ion batteries, developed under the project "CODEVELOP-GT/0322/0081 - REAl LIve SimulATION of GREEN software in the CLOUD," a collaboration between KYAMOS LTD and Frederick University. The methodology utilizes the Lattice Boltzmann Method with a Multiple Relaxation Time collision model and a D3Q27 lattice Boltzmann stencil in three-dimensional space to model complex bicontinuous porous structures for the anode and cathode. This approach accurately simulates critical electrochemical and transport processes, including mass transport, charge transfer, and fluid dynamics, within intricate electrode microstructures. The LBM-MRT framework ensures numerical stability and precision, supported by a solver written in C++ CUDA that harnesses Nvidia GPUs for efficient parallel processing. The solver is paired with an intuitive GUI, allowing users to define boundary and initial conditions, create unique bicontinuous microstructures, and visualize results such as lithium-ion concentration, electric field values, and current/voltage profiles. This comprehensive tool facilitates the design and optimization of lithium-ion batteries, offering valuable insights into next-generation energy storage solutions. Conducted within the CODEVELOP-GT initiative, this work integrates cloud-based green software principles with high-performance computing, contributing to sustainable technology development. The collaboration between KYAMOS LTD and Frederick University unites industry innovation with academic expertise, delivering a scalable and user-friendly platform for advanced battery simulations that pushes the boundaries of computational electrochemistry.

CASE25_EE_I_13 — Advanced 3D Simulation of PN-Junctions Using the Lattice Boltzmann D3Q19 Model

A. Papadakis[1,2]*, V. Mikromatis[2]**, S. Pigiotis[2]***
[1]Department of Electrical Engineering, Computer Engineering and Informatics, Frederick University, Nicosia, 1036, Palouriotissa, Cyprus
[2]KYAMOS LTD, 37 Polyneikis Street, Strovolos, Nicosia 2047, Cyprus
*E-mail: a.papadakis@frederick.ac.cy, apapadakis@kyamosmultiphysics.com
**E-mail: vmikromatis@kyamosmultiphysics.com
***E-mail: spigiotis@kyamosmultiphysics.com

Abstract. This study presents a comprehensive simulation framework for PN-junction analysis using the Lattice Boltzmann D3Q19 model, a study performed by KYAMOS Multiphysics Limited in collaboration with Frederick University. This model enables detailed three-dimensional simulations, capturing charge carrier dynamics such as drift and diffusion under varying bias conditions. The D3Q19 model ensures isotropic behaviour, reducing artifacts and enhancing consistency. It also serves as a foundation for advanced transport models, crucial for accurately depicting carrier energy behaviour in power electronic devices. A core component of our workflow involves solving Poisson's equation across a 3D lattice to determine the electric potential distribution, directly influencing carrier motion. Dirichlet boundary conditions are applied to model forward and reverse bias voltages, while the electric field is computed within the LB framework to ensure precise charge carrier drift modelling. Carrier transport is described using the time-dependent convection-diffusion equation, incorporating diffusion, drift, and generation-recombination effects. Several recombination mechanisms, including impact ionization, Auger, band-to-band, and Shockley-Read-Hall recombination, are explicitly modelled for accuracy. To optimize performance, a CUDA-aware MPI software is developed for efficient interpolation within the LB mesh. Our model will be benchmarked against AMPS-1D and PySpice simulations, including real-world devices like 1N4148 and BAV21 diodes. Additionally, these simulations contribute to developing a sophisticated module for Silicon Carbide (SiC) semiconductor devices, aiding in device optimization. We also introduce a user-friendly Graphical User Interface for setting up and managing semiconductor simulations developed by KYAMOS Limited. It allows users to configure key parameters, integrates real-time visualization, and supports automated configuration file generation, improving accessibility and reducing errors. This framework advances semiconductor modelling, offering an efficient tool for researchers and engineers in power electronics.

EE02 - Communications

CASE25_EE_I_02 — True Time Delay Bandpass Filters for FR-3 Band Beamforming: A Triple-Tapered Stub Approach.

Charalampia Chatzi[1]*, George Kyriacou[2]*

[1] Department of Electrical and Computer Engineering and Informatics, Frederick University, Nicosia, Cyprus

[2] Department of Electrical and Computer Engineering, Democritus University of Thrace, Xanthi, Greece

*E-mail: st028520@stud.frederick.ac.cy, gkyriac@ee.duth.gr

Abstract. This paper presents a comprehensive study on the design of bandpass True Time Delay (TTD) filters, intended to be used in beamforming networks for wideband phased antenna array systems. The filters operate within a segment of the FR3 frequency band (7-24 GHz), specifically covering the 7-16 GHz range. In wideband phased array systems, it is necessary to ensure that the group delay response remains constant, with minimal ripple, to maintain a linear phase response. These filters help to address the challenges of wideband beamforming and to mitigate critical issues, such as signal distortion and beam squint, an effect where the beam direction shifts with frequency, especially if conventional narrowband phase-shifting techniques (phase shifters) are used. The proposed filters are exclusively passive and specifically are constructed using microstrip transmission lines and short-circuited stubs. A key feature of the design is the use of a triple-tapered stub to achieve the desired flat group delay response while reducing the overall size of the filter. The main aim is to achieve a maximally flat group delay response, which is equivalent to a linear phase response. Also, the design methodology is quite simple. After a thorough background theoretical research, schematic-level and electromagnetic simulations were performed to ensure accurate and reliable results. Performance metrics such as group delay flatness, insertion loss, and return loss were analysed and optimized across the targeting operating frequency band. Simulation results demonstrated a group delay variation of less than 10% and a return loss better than -10 dB for 90% of the passband, indicating good impedance matching and group delay flatness. Given the aforementioned characteristics, the proposed bandpass filters are highly suitable for integration into beamforming networks used in 5G infrastructure, satellite communications, radar applications and other high-frequency applications. This paper also discusses design trade-offs, practical implementation challenges, and aims to offer useful guidelines for future filter development efforts.

CASE25_EE_I_03 — Investigation of Precipitable Water Vapor (PWV) and heavy rainfall relationship over coastal regions in Cyprus

Christina Oikonomou[1,2]*, Haris Haralambous[2,3], Despoina Giannadaki[1], Filippos Tymvios[4]
[1]Cloudwater Ltd, Nicosia, Cyprus
[2]Frederick Research Center, Nicosia, Cyprus
[3]School of Engineering, Frederick University, Nicosia, Cyprus
[4] Department of Meteorology, Nicosia, Cyprus
*E-mail: res.cc@frederick.ac.cy

Abstract.
Nowcasting of localised abrupt extreme rainfall events is a challenging task that requires the combined investigation of heterogenous (both ground- and space-based) datasets. Atmospheric water vapor (WV) which is the most abundant greenhouse gas (accounting for ~70% of global warming) comprises a significant energy source which generates severe weather and climate phenomena. The rapid spatiotemporal variations of WV in the low atmosphere poses one of the main challenges to NWP (Numerical Weather Prediction) models forecasting accuracy. Abrupt increase of WV several hours before extreme rainfall has been temporally correlated with rainfall in various studies, followed by a decrease after the event. Other studies have investigated the joint effect of WV and atmospheric pressure on extreme rainfall. Though many studies have evidenced ongoing accumulation of WV before the heavy rainfall, there is still a great difficult to determine a tight relationship between rainfall and WV, that could be reproduced by a plain, physically motivated two-layer nowcasting model. In this context, the present study attempts a first comparison of PWV with the respective rainfall measurements with the ultimate aim to investigate the possible correlation between WV and heavy rainfall, during a selected extreme precipitation event occurring during 19-31 December 2024 over coastal regions in Cyprus Island. To achieve this, we exploited ERA5 Reanalysis dataset and rainfall observations, owned by the Department of Meteorology of Cyprus.

CASE25_EE_I_07 — Ionospheric response of the January 2025 geomagnetic storm over Europe

Krishnendu Sekhar Paul[1]*, Haris Haralambous[1,2]
[1]Frederick Research Center, Nicosia, Cyprus
[2]Department of Electrical and Computer Engineering and Informatics, Frederick University, Nicosia, Cyprus
*E-mail: res.pk@frederick.ac.cy

Abstract.
The present study examines the ionospheric response over Europe during the first geomagnetic storm of 2025. The storm, with a peak Dst value of −200 nT, occurred in the interval 1–2 January 2025. Using data from a number of European locations, temporal and spatial variations in ionospheric parameters (TEC, foF2, and hmF2) were analyzed to investigate the morphology of the ionospheric response. Sharp electron density (Ne) depletion is associated with the equatorward displacement of the Midlatitude Ionospheric Trough (MIT), was confirmed by Swarm satellite data. A key finding was the absence of foF2 and hmF2 values over certain ionosonde stations during the recovery phase of the storms, likely due to the coupling between the Equatorial Ionization Anomaly (EIA) crests and the auroral ionosphere influenced by the intense uplift of the F layer. Relevant distinct features such as Travelling Ionospheric Disturbances (TIDs) signatures and Spread F were also noted, particularly during the initial and main phase of the first storm over high midlatitude regions. Regional effects varied, with high European midlatitudes exhibiting different features compared to lower European latitude areas.

CASE25_EE_I_08 — Liquid Antennas as Components For Sustainable Wireless Systems

Adnan Nadeem[1,3], David Chatzichristodoulou[1,2], Nosherwan Shoaib[4], Photos Vryonides[1,3], Symeon Nikolaou[1,3]*

[1]Frederick Research Center, Nicosia, Cyprus

[2]RF and Microwave Solutions LTD, Cyprus

[3]Department of Electrical Engineering, Frederick University, Nicosia, Cyprus

[4]School of Electrical Engineering and Computer Science (SEECS), National University of Sciences and Technology (NUST), Islamabad, Pakistan

*E-mail: s.nikolaou@frederick.ac.cy

Abstract.

The recent advancements in wireless communication technologies require the development of sustainable and reconfigurable antenna systems. Liquid antennas have emerged as a promising solution due to their reconfigurability, and their physical implementation using environmentally friendly composite conductive materials in combination with recyclable dielectrics. Unlike conventional metal-based antennas, liquid antennas utilize conductive fluids, such as nanocomposite materials or liquid metals, which can be dynamically reshaped to optimize performance across multiple frequency bands. In addition, the carrier substrate can be 3D printed recyclable or even biodegradable dielectric materials. This adaptability reduces the need for multiple fixed antennas, thereby lowering material consumption and electronic waste, contributing to the sustainability of electronic systems. The integration of liquid antennas with 3D printing technologies presents a novel approach in designing next-generation communication systems. Additive manufacturing enables precise, customized, and scalable production of antenna structures, enabling complex geometries that optimize the RF performance while minimizing the material waste. By leveraging 3D printing for electronics, researchers can fabricate encapsulated structures and microfluidic channels to contain liquid conductors or even liquid dielectrics, ensuring stable performance while maintaining the flexibility of the radiator. Additive manufacturing can also support the implementation of more complex structures such as antenna arrays or metasurfaces that can be used for the next generation communication systems. This paper explores the design and implementation of a sub-6 GHz annular slot antenna with additively manufactured fluidic channels that enable the creation of radiation pattern null directions. Furthermore, it highlights the role of additive manufacturing in advancing the fabrication possibilities of liquid antennas, providing customized cost-effective and diverse low TRL prototypes. The combination of these technologies, can pave the way for environmentally friendly, high-performance, and energy-efficient wireless systems, aligning with the goals of sustainable development and green innovation

CASE25_EE_I_09 — Additively Manufactured RF Components Using Nanocomposite Conductive Materials and Non_x0002_Homogeneous Dielectric Substrates

David Chatzichristodoulou[1,2], Adnan Nadeem[1,3], Evangelos E. Melagrakis[5], Georgios Michalis[6], Nosherwan Shoaib[4], Photos Vryonides[1,3], Symeon Nikolaou[1,3]*

[1] Frederick Research Center, Nicosia, Cyprus

[2] RF and Microwave Solutions LTD, Cyprus

[3] Department of Electrical Engineering, Frederick University, Nicosia, Cyprus

[4] School of Electrical Engineering and Computer Science (SEECS), National University of Sciences and Technology (NUST), Islamabad, Pakistan

[5] Calculus IKE, Piraeus, Greece

[6] Fractal Network Ltd, Nicosia, Cyprus

*E-mail: s.nikolaou@frederick.ac.cy

Abstract.

The evolution of radio frequency (RF) electronics demands innovative substrate materials and fabrication techniques to enhance performance while ensuring cost-effectiveness environment friendliness and sustainability. Additive manufacturing (AM) has emerged as a transformative approach for fabricating RF components and RF substrates, offering design flexibility, reduced material waste, and the ability to create complex, customized geometries. Unlike conventional subtractive methods, AM enables the precise control of material distribution and structural properties, facilitating the fabrication of substrates tailored for specific RF applications. One promising advancement in AM for RF electronics, is the use of nonhomogeneous substrates with spatially varying dielectric constants. By engineering substrates with gradient or region-specific permittivity (εr), designers can optimize electromagnetic wave propagation, reduce losses, and enhance impedance matching for improved RF performance. This approach is particularly advantageous for antennas, filters, and impedance-matching networks, where tailored dielectric properties can lead to higher efficiency and bandwidth optimization. The incorporation of multi-filament materials in AM further expands the possibilities for RF substrate design. By combining high-permittivity (high εr) materials with low-loss (low tanδ) materials, it is possible to achieve superior RF characteristics. These hybrid materials can be precisely deposited to create functionally graded structures that balance dielectric properties and mechanical strength, enhancing superior RF performance. Additionally, the development of nanocomposite conductive materials and their use for the implementation of passive RF components presents significant advantages. Conductive nanomaterials, such as silver or carbon-based composites, enable the fabrication of high-performance RF components, including antennas and filters, with improved electrical conductivity and reduced surface roughness while the components remain recyclable and even biodegradable. This paper explores the potential use of AM for RF electronics, through the comparative study of a UHF antenna and a bandpass filter (BPF) at 1.6 GHz as potential candidates for recyclable, sustainable passive RF components.

CASE25_EE_I_10 — Challenges in Improving GNSS positioning over Cyprus by ingesting ionospheric characteristics into an ionospheric mitigation algorithm

Trisani Biswas[1,2]*, Vasilis Petrou[1], Haris Haralambous[2,3]
[1]GeoImaging Ltd., 2021 Nicosia, Cyprus
[2]Department of Electrical and Computer Engineering and Informatics, Frederick University, Nicosia, Cyprus
[3]Frederick Research Center, Nicosia 1036, Cyprus
*E-mail: res.bt@frederick.ac.cy

Abstract.
Single-frequency Global Navigation Satellite System (GNSS) ionospheric mitigation over a certain area is an important capability for accurate positioning for low-cost mobile platforms such as phones and tablets. GNSS systems such as GALILEO rely on an underlying ionospheric model (NeQuick-G) to facilitate this capability. The concept of ingesting regional ionospheric characteristics measured by a digital ionosonde to drive the NeQuick-G algorithm as opposed to a global scale representation, has been recently explored in the frames of a research project. This approach facilitates the local adjustment of Committee Consultative for Ionospheric Radiowave propagation (CCIR) files and the Az ionization level, which control the ionospheric electron density profile in NeQuick-G, therefore enabling better estimation of positioning errors under quiet geomagnetic conditions. This novel concept for local ionospheric positioning error mitigation may be adopted at any location where ionospheric characteristics can be measured, as a means to enhance the accuracy of single-frequency positioning applications based on the NeQuick-G algorithm. In this paper we demonstrate the application of this concept over Cyprus and highlight certain challenges that need to be addressed to improve the performance of such a solution.

CASE25_EE_I_12 — RF Filter Architectures for Tuneable and Reconfigurable Communication System

A. Papadakis[1,2]*, I. Iliofotou[2]**, A. Costa[2]***
[1] Department of Electrical Engineering, Computer Engineering and Informatics, Frederick University, Nicosia, 1036, Palouriotissa, Cyprus
[2] KYAMOS LTD, 37 Polyneikis Street, Strovolos, Nicosia 2047, Cyprus
*E-mail:a.papadakis@frederick.ac.cy, apapadakis@kyamosmultiphysics.com
**E-mail: iiliofotou@kyamosmultiphysics.com
***E-mail: acosta@kyamosmultiphysics.com

Abstract.
This work presents an innovative software architecture for the simulation of advanced RF filters, specifically focusing on non-reciprocal bandpass filters (BPFs). The software features a user-friendly graphical interface, where calculations are performed using CUDA, MPI, and parallel programming techniques to achieve high computational efficiency. The underlying numerical scheme is based on a novel finite-difference time-domain (FDTD) modeling technique, which extends the modified Telegrapher's equations to facilitate the simulation of discrete time-invariant and time-variant inductance (L) and capacitance (C) components, as well as LC resonators. This approach enables the accurate design and analysis of RF components, particularly non-reciprocal BPFs. In this work, the developed software is employed to simulate time-variant resonators for non-reciprocal filtering applications. The effectiveness of the method is demonstrated through the modeling of various non-reciprocal filtering structures, including a three-pole BPF and a three-pole/two-transmission zero (TZ) non-reciprocal BPF. The accuracy of the simulations is validated by comparing the results with harmonic balance simulations performed in Keysight ADS, confirming the reliability of the proposed approach. By leveraging advanced numerical techniques and scalable parallel computing methodologies, the software significantly accelerates simulation times while maintaining high accuracy. This computational efficiency is particularly crucial for the design and optimization of next-generation RF components, where fast and accurate modeling is essential. The proposed software represents a significant step toward enabling high-performance, non-reciprocal filter designs for future communication systems, particularly in the FR1 and FR2 bands. The combination of innovative algorithmic developments with high-performance computing underscores the potential for transformative advancements in RF filter design and simulation.

ME01 - Innovative Renewable and Hydrogen Solutions

CASE25_ME_E_05 — Residual-Refined Temporal Fusion Transformer for Occupancy-Aware Day-Ahead Energy Forecasting

Stavros Koltsios[1,2]*, Charalamos Bazakas[1]*, Aggeliki Velisaki[1], Elias B. Kosmatopoulos[1,2], Dimosthenis Ioannidis[1], Dimitrios Tzovaras[1]

[1] Information Technologies Institute, Centre for Research & Technology, Thessaloniki, 57001, Greece

[2] Department of Electrical and Computer Engineering, Democritus University of Thrace, Xanthi, 67100, Greece

*Contributed Equally.

*E-mail: skoltsios@iti.gr, ch.bazakas@iti.gr, kosmatop@iti.gr, a.velisaki@iti.gr, kosmatopoulos@iti.gr, d.ioannidi@iti.gr, Dimitrios.Tzovaras@iti.gr

Abstract.

Accurate day-ahead energy consumption forecasts are central to modern power system stability and market efficiency, enabling operators to balance supply and demand while minimizing operational costs. To address this need, the Residual-Refined Temporal Fusion Trans- former (RR-TFT) is proposed, a novel hybrid deep learning architecture that builds upon the Temporal Fusion Transformer (TFT), enriched with residual-refinement blocks and explicit integration of occupancy signals. The model leverages both past and future timevarying covariates—including motion-based occupancy data—as well as static contextual features, enabling it to capture both human-driven variability and longterm temporal dependencies. The proposed approach retains the TFT's powerful components: dynamic variable selection, gated residual networks, and interpretable multi-head self-attention, which collectively allow the model to focus on the most relevant features across time. A key innovation is the introduction of stacked residual-refinement blocks that iteratively correct the primary forecast by learning and adjusting residual errors. This dual-stage design enables the model to handle complex patterns, such as abrupt load spikes linked to occupancy fluctuations, which are often missed by single-pass architectures. Occupancy features are incorporated not only as direct inputs but also as conditioning signals in the model's variable selection and static encoding stages, allowing the network to modulate its attention based on presence-driven energy dynamics. This proves especially effective in modelling event-driven or irregular usage periods. The method is benchmarked against several baseline models— LSTM, Seq2Seq with Bahdanau attention, standard Transformer, and original TFT—using a real-world smart building dataset with 15-minute resolution. The proposed model achieves superior accuracy across all metrics: MAE = 0.1738, MSE = 0.0722, and R^2 = 0.8137, while maintaining interpretability. It is thus well-suited for deployment in smart building environments requiring responsive, humanaware energy forecasting.

CASE25_ME_E_08 — Experimental Investigation and Nonlinear Finite Element Analysis of Corroded Reinforced Concrete Elements Retrofitted with Strain-Hardening Cementitious Composites (SHCCs) and Fiber-Reinforced Polymers (FRPs)

Nikolaos Tzavellos[1], Christos Petrides[1], Salomi Papamichael[1], Natia R. Anastasi[1], Aikaterini S. Genikomsou[2], Anthos I. Ioannou[1]*

[1] Department of Civil Engineering, Neapolis University Pafos, Danas 2, 8042 Pafos, Cyprus

[2] Department of Civil Engineering, Queen's University, 58 University Avenue, Kingston, K7L 3N6, Ontario, Canada

*E-mail: a.ioannou.7@nup.ac.cy

Abstract.

Corrosion-induced deterioration of reinforced concrete (RC) structures remains a major concern in structural engineering, especially in coastal or chloride-rich environments. This study investigates the structural performance of corroded RC elements strengthened with Strain-Hardening Cementitious Composites (SHCCs) and FiberReinforced Polymers (FRPs) using a combined experimental and numerical approach. RC specimens are subjected to accelerated corrosion via the impressed current technique, then retrofitted either with SHCC overlays or externally bonded FRPs. The experimental phase, currently in progress, includes flexural tests to evaluate the retrofits in terms of load-bearing capacity, ductility, and failure mechanisms. Image-based deformation measurements complement these tests, providing data for the validation of advanced nonlinear finite element models developed in ABAQUS. These models incorporate both corrosion-induced material degradation and the complex behaviour of the retrofitted systems under monotonic loading. The main objectives are to: (i) quantify the mechanical degradation caused by corrosion, (ii) compare the effectiveness of SHCC and FRP retrofits, (iii) assess the predictive accuracy of finite element models in capturing nonlinear response, and (iv) identify effective strategies for modelling corrosion in RC members. The findings aim to inform the design of durable and efficient retrofitting solutions, improving the resilience of aging infrastructure exposed to aggressive environments.

CASE25_ME_E_10 — Introduction to the creation of a method for short-term forecasting of energy yield from solar thermal collector

Gabriela Sadowska[1], Tomasz Cholewa[1]
[1]Faculty of Environmental Engineering, Lublin University of Technology, Lublin, Poland
*E-mail: gabriela.sadowska@pollub.edu.pl, t.cholewa@pollub.pl

Abstract: Currently, the essensial energy needed to meet the needs of society is largely obtained from traditional, conventional energy sources that generate negative effects on the environment. Nevertheless, renewable energy sources (RES) are gaining importance, both as a result of the growing ecological awareness of society and in response to increasingly restrictive EU regulations that impose obligations regarding the share of RES in national energy balances. Due to the difficulties associated with storing energy from RES and the challenges associated with forecasting their efficiency, there is a need to develop methods for forecasting energy yields from photovoltaic systems. The aim of this paper is to present the basic assumptions regarding the development of a method for short-term forecasting of energy yields from solar collectors installed in a multi-family building.

CASE25_ME_E_15 — Perspective of Shallow Geothermal Systems in the Republic of Croatia

Vladimir Soldo[1]*, Luka Boban[1], Stjepan Herceg[1], Marija Macenić[2], Tomislav Kurevija[2]
[1]University of Zagreb, Faculty of Mechanical Engineering and Naval Architecture, Zagreb, Croatia
[2]University of Zagreb, Faculty of Mining, Geology and Petroleum Engineering, Zagreb, Croatia
*E-mail: vsoldo@fsb.hr

Abstract. Due to its geographical and geological position, the Republic of Croatia has significant potential for utilizing shallow geothermal energy. This potential was recognized by Croatia's Integrated National Energy and Climate Plan, which provides guidelines for broader implementation. The first research in in the field of geothermal heat pump systems was carried out within the project Heat Pumps Coupled to the Ground as a Renewable Energy Sources (2007-2013). Especially valuable in-situ research was carried out within the IPA IIIC project Research and the Promotion of the Use of Shallow Geothermal Potential in Croatia – GeothermalMapping (2013-2015). At eight locations throughout Croatia thermal properties of the soil were determined using the advanced Distributed Thermal Response Test - DTRT method. These national results were used for further promotion of technology and the education of end users. Several Interreg, Horizon, EED geothermal projects have ensued.

The first comprehensive review of heating and cooling systems that use renewable shallow geothermal energy as a source was conducted within the PLIGES project—Mapping of Shallow Geothermal Systems in the Republic of Croatia (2023-2024). A database of installed geothermal heat pumps was developed, and an interactive GIS map, which is continuously updated. There are approximately the same number of installed systems with water and soil as a heat source/sink. Estimated production of annual thermal energy from shallow geothermal systems is close to 70,000 MWh, while savings in carbon dioxide emissions amount to 11,800 tons. The project was carried out by the University of Zagreb and was funded by Iceland, Liechtenstein, and Norway under the European Economic Area (EEA) Financial Mechanism 2014–2021.

CASE25_ME_I_12 — Energy transition in European Union after the unprecedented energy crisis

Venizelos Venizelos[1], Andreas Poullikkas[2]
[1] Agency for the Cooperation of Energy Regulators, Trg republike 3, SI-1000 Ljubljana, Slovenia
[2] School of Engineering, Frederick University, 7 Frederickou Street, 1036 Nicosia, Cyprus
*E-mail: a.poullikkas@frederick.ac.cy

Abstract.
The unprecedented energy crisis in the European Union (EU), driven by geopolitical tensions, volatile natural gas prices, and the lingering effects of the COVID19 pandemic, has catalyzed significant structural and economic changes within the energy sector. This paper examines the crisis' systemic impacts, emphasizing the sharp increases in energy prices and the volatility in electricity markets that highlighted the vulnerabilities of the existing market design. The undertaken analysis addresses critical market reforms, including the use of long–term instruments which are pivotal for mitigating market volatility and incentivizing renewable investments. The study also focuses on the evolving role of hydrogen as a key enabler of the energy transition, exploring its potential to decarbonize energy–intensive sectors and stabilize grids while fostering the development of a super smartgrid interconnecting Europe with North Africa and the Middle East. Such integration leverages complementary renewable resources across regions, enhancing energy security and reducing dependency on fossil fuels. By presenting actionable recommendations for policy and market design, this work contributes to the discourse on achieving a sustainable and resilient energy system in the EU, paving the way for a secure hydrogen economy and deeper transcontinental energy collaboration.

CASE25_ME_I_22 — Green Hydrogen Production by Using Recycle Aluminum Metal Without the Use of Electricity

Demetrios Hadjipetrou[1,2]*, Christodoulos N. Christodoulou[1,2], George Karagiorgis[1,2], Michalis Menicou[1]

[1] Mechanical Engineering, Frederick University, Nicosia, Cyprus

[2] Hystore Tech Ltd, Nicosia, Cyprus

*E-mail: st015568@stud.frederick.ac.cy

Abstract.

Hydrogen is increasingly recognized as a clean and flexible energy carrier with significant potential to support the transition away from fossil fuels and toward renewable energy systems. Among the various methods for producing hydrogen, the reaction between aluminum and alkaline solutions stands out for its simplicity and efficiency, especially when aluminum waste is used as the source material. While aluminum recycling is widely promoted for its environmental benefits, its wider adoption is often hindered by high energy requirements, economic limitations, and operational challenges. This study explores an innovative solution that combines aluminum waste recycling with green hydrogen production, offering a dual benefit: sustainable energy generation and effective waste reduction. The experimental investigation focused on the reaction kinetics of aluminum with aqueous sodium hydroxide (NaOH), analyzing how factors such as surface area, NaOH concentration, and temperature affect hydrogen output over time. The findings demonstrated a strong correlation between the experimental data and theoretical stoichiometric predictions. Importantly, NaOH acted as a catalyst rather than being consumed, supporting continuous hydrogen production. The H2 production rate is expected to be higher for aluminum shavings than for the aluminum cans and aluminum slabs. This approach was successfully applied to an electric scooter adapted for individuals with disabilities. Practically, one kilogram of aluminum produces 1246NLiters of hydrogen, which, with the use of PEM Fuel Cell extended the scooter's travel range about twice as much the distance achievable on a full battery charge. The results highlight the promise of this method as a sustainable and scalable technology that aligns environmental responsibility with practical energy needs.

CASE25_ME_I_23 — Hydrogen enhanced efficiency of Gas Burners for Central Heating Boilers

Kypros Demetriou[1,2]*, Christodoulos N. Christodoulou[1,2], George Karagiorgis[1,2], Michalis Menicou[2]

[1] Hystore Tech Ltd, Nicosia, Cyprus

[2] Mechanical Engineering, Frederick University, Nicosia, Cyprus

*E-mail: eng.kg@frederick.ac.cy

Abstract.

The quest for sustainable energy solutions has led to innovative approaches in various industrial sectors, including combustion systems. This is a detailed investigation into the potential enhancement of gas burner ef□iciency through the addition of HHO gas-a sustainable mixture of hydrogen and oxygen. This hypothesis suggests that incorporating HHO gas into the combustion process can lead to signi□icant improvements in operational ef□iciency while, at the same time, reducing exhaust gas emissions. This study meticulously outlines the experimental setup, research methodology, and data collection procedures aimed at substantiating this hypothesis, by precisely controlling the □low of HHO gas into the gas burner, achieving a dual-purpose objective of conserving fuel resources and mitigating environmental impact. Initial phases involve establishing baseline performance with LPG operation, followed by systematic introduction of HHO gas to evaluate its impact on combustion dynamics. Key parameters such as temperature and LPG/HHO fuel consumption are rigorously monitored to generate a comprehensive dataset facilitating insights into the complex interactions between HHO gas addition and burner ef□iciency. Experimental results showed a remarkable increase in ef□iciency by 10% and to substantial reduction in exhaust gas emissions, with an impressive 81% and 53% decrease in unburnt hydrocarbons (UH) and in carbon monoxide (CO), correspondingly. The □indings of this study hold promise for advancing sustainable combustion technologies and fostering environmental stewardship in many industrial applications, such as central heating boilers, gas-turbines-etc.

ME02 - Advancing Smart and Integrated Building Assessment

CASE25_ME_E_01 — Rethinking building assessment: Beyond Energy Performance Certificates and the Smart Readiness Indicator in the Greek context

Christina Mykoniou[1]*, Zoi Boutopoulou[1], Afroditi Zamanidou[1], Paraskevas Koukaras[2], Dimosthenis Ioannidis[2], Dimitrios Tzovaras[2]

[1] Intelligent Solutions for Zero and Positive Energy Buildings (IsZEB), 6th km Charilaou-Thermi, Thessaloniki, Greece

[2] Information Technologies Institute, Centre for Research and Technology Hellas, 6th km Charilaou-Thermi, Thessaloniki, Greece

*E-mail: c.mykoniou@iszeb.gr

Abstract.

The pursuit of resilient, sustainable and high-performance structures has emerged as a key priority in contemporary urban development. The European Union's policy around the construction sector aims to establish robust legislation frameworks and strategies to facilitate decarbonization, enhance building efficiency and alleviate energy poverty by 2050. In this context, assessment tools such as the Energy Performance Certificates (EPCs) and the Smart Readiness Indicator (SRI) have been developed to evaluate and improve the energy performance of buildings. While each of these methodologies provides a systematic approach to assess energy efficiency and building intelligence, their perspective on overall building performance analysis is limited, in terms of encompassing holistic sustainability aspects. In parallel, stakeholders around the world have introduced various certification systems of buildings, taking into account the three fundamental pillars of sustainability: environment, economy and society. However, the existing schemes do not adequately integrate both energy efficiency and building smartness, while also overlooking characteristics of the Greek building stock and domestic construction regulations. Against this backdrop, the current research aims to explore the need for the development of a dynamic, high-granularity framework that builds upon EPCs, leverages key elements of the SRI methodology and incorporates broader sustainability parameters. Through comprehensive literature review, desk research and stakeholder involvement, this study intends to refine the overall buildings' energy performance evaluation, in alignment with national and European standards. It examines a range of critical factors impacting building energy efficiency and smartness, along with additional social dimensions, including user health and safety. The overarching goal is the proposal of specific evaluation levels for building assessment within an extensive, more integrated scheme. The anticipated outcomes have the potential to lay the fundamentals for the development of a holistic evaluation methodology and to guide the transition toward a smarter, more sustainable and human-centered built environment in Greece.

CASE25_ME_E_04 — Smart assessment in the context of urban decarbonization: Comparative analysis and methodological insights through the case study of Western Macedonia Region in Greece

Afroditi Zamanidou[1]*, Konstantinos Chatzikonstantinidis[2], Konstantinos Zamanidis[3], Georgios C. Christoforidis[1]

[1] School of Engineering, Department of Electrical & Computer Engineering, University of Western Macedonia, Kozani, Greece

[2] Process Equipment Design Laboratory, School of Mechanical Engineering, Aristotle University of Thessaloniki, Thessaloniki, Greece

[3] School of Economic Sciences, Department of Statistics, University of Western Macedonia, Grevena, Greece

*E-mail: a.zamanidou@uowm.gr

Abstract.

As cities and regions pursue ambitious decarbonization goals under the twin pressures of climate change and digital transformation, assessing their level of smart readiness has become essential. While the concept of smart urban environments is gaining traction, the methodologies for evaluating their smartness remain heterogeneous and often lack direct alignment with sustainability and carbon neutrality targets. This paper presents a comparative analysis of existing assessment frameworks for urban smartness in the context of decarbonization, including the Smart Readiness Indicator (SRI), the European Smart City Model, ISO 37122 (Indicators for Smart Cities), the CityKeys framework, and the UN-Habitat City Prosperity Index. Through a deep literature review and a structured scoring system, each framework is evaluated against a set of criteria capturing technical, environmental, social and governance dimensions, with a particular focus on interoperability, energy integration, user-centric design and climate impact. The comparative analysis is connected with the case study of Western Macedonia in Greece, a former coal-dependent region undergoing a significant transition toward a climate-neutral and carbon free economy. By mapping the region's current status against key indicators from the selected frameworks, the study identifies critical gaps, overlaps and opportunities for integrating smart readiness assessments into regional planning. The results underline the need for a more coherent and context-sensitive evaluation scheme that bridges urban intelligence with decarbonization imperatives. This work contributes to the ongoing dialogue on how to operationalize smartness at urban and regional scales, offering practical insights for policymakers, planners and stakeholders engaged in sustainable urban transitions.

CASE25_ME_E_16 — The 2024 recast EPBD: What HVAC and building professionals need to know?

Andrei V. Litiu[1]*, Paris A. Fokaides[2], Johann Zirngibl[1,3], Jarek Kurnitski[1,4], Jaap Hogeling[1,3], Pablo Carnero Melero[3], Francesco Robimarga[3]

[1] EPB Center, Rotterdam, Netherlands

[2] Frederick University, Nicosia, Cyprus

[3] REHVA, Brussels, Belgium

[4] TalTech, Tallinn, Estonia

*E-mail: avl@epb.center

Abstract.

The 2024 recast of the Energy Performance of Buildings Directive (EPBD IV) redefines the role of HVAC professionals, placing them at the centre of the EU's strategy for decarbonising its building stock. This paper explores how new policy provisions, including mandatory Building Automation and Control Systems (BACS) and the voluntary Smart Readiness Indicator, Minimum Energy Performance Standards (MEPS), enhanced Energy Performance Certificates (EPCs) and Renovation Passports (RPs), and Indoor Environmental Quality (IEQ) safeguards, are reshaping expectations and workflows across the HVAC sector. Drawing on the final EPBD text, the study outlines both the compliance challenges and the business opportunities stemming from this evolving regulatory landscape. Key focus areas include the integration of smart-ready technologies, the operationalisation of IEQ metrics, and the upskilling needs of the HVAC workforce. By examining the directive's practical implications for designers, installers, facility managers, and energy auditors, the paper argues that the HVAC profession is not merely subject to EPBD compliance, but is now a strategic enabler of Europe's climate, energy security, and digitalisation goals. The work concludes by identifying pathways through which HVAC stakeholders can lead the transformation from regulatory burden to market-driven innovation.

CASE25_ME_E_18 — Combined Evaluation of the Smart Readiness Indicator (SRI) and the Energy Performance Certificate (EPC) in Residential Building Renovation

Konstantinos Chatzikonstantinidis[1]*, Effrosyni Giama[1], Agis M. Papadopoulos[1]
[1]Process Equipment Design Laboratory, School of Mechanical Engineering, Aristotle University of Thessaloniki, 54124, Thessaloniki, Greece
*E-mail: kchatziko@auth.gr

Abstract.
The transition towards climate-neutral and resilient buildings in the European Union necessitates robust evaluation tools that capture both energy efficiency and smart functionality. This paper investigates the combined use of the Energy Performance Certificate (EPC) and the Smart Readiness Indicator (SRI) in the context of residential building renovation. Through a detailed case study of a four-story apartment building in Thessaloniki, Greece, three renovation scenarios were assessed: (i) the original pre-renovation state, (ii) a passive energy upgrade scenario, and (iii) a smart technology upgrade scenario. The results highlight the distinct and complementary roles of the two indicators. While the EPC reflects substantial improvements in energy consumption—dropping from 331.6 to 52.5 kWh/m^2·year in the passive scenario—it fails to capture gains in automation, control, and user responsiveness. Conversely, the SRI score increased from 11.7% to 62.3% in the smart renovation scenario, demonstrating significant enhancement in operational intelligence and flexibility, despite only moderate changes in energy use. These findings suggest that EPC and SRI offer orthogonal but synergistic insights into building performance and should be jointly applied to guide renovation strategies under the EU Green Deal and Renovation Wave. The study advocates for hybrid renovation pathways that integrate both energy and smart readiness upgrades to maximize building sustainability, efficiency, resilience and adaptability. Keywords: Smart Readiness Indicator (SRI), Energy Performance Certificate (EPC), Buildings, Energy Efficiency, Smart Technologies

CASE25_ME_I_06 — Smart Data Collection for Building Sustainability Assessment: The Case of Call Centres and the Smart Readiness Indicator

Paris A. Fokaides[1]*, Nicholas Afxentiou[1], Pablo Carnero Melero[2], Marco Pietrobona[3], Afroditi Zamanidou[4]

[1] School of Engineering and Applied Sciences, Frederick University, 7, Y. Frederickou Str., 1036 Nicosia, Cyprus

[2] Federation of European Heating, Ventilation and Air Conditioning Associations (REHVA), Brussels, Belgium

[3] MZ Solutions, Pavia della Vittoria, 2, 27100 Pavia, Italy

[4] Electrical & Computer Engineering Department, Faculty of Engineering, University of Western Macedonia, Greece / Intelligent Solutions for Zero and Positive Energy Buildings (IsZEB), 6th km Charilaou-Thermi, Thessaloniki, Greece

*E-mail: p.fokaides@frederick.ac.cy

Abstract.

The Smart Readiness Indicator (SRI) is an initiative by the European Commission under the Energy Performance of Buildings Directive, designed to assess a building's capability to integrate smart technologies. These technologies contribute to decarbonization while enhancing comfort and energy efficiency. A building's smartness refers to its ability to detect, interpret, communicate, and efficiently respond to changing conditions related to technical building systems, the external environment, including energy grids, and occupant needs. This research examined the implementation of call centre questionnaires as an innovative tool for SRI data collection. The methodology involves a structured data collection process leveraging call centre interactions to evaluate building smart readiness indicators effectively. It examines over 3000 responses from ten countries: Germany, France, Spain, Italy, Greece, Cyprus, Poland, Lithuania, Denmark and Croatia, providing valuable insights into building smart readiness across different regions. This approach addresses common challenges in SRI assessment, such as scalability, cost, and precision. Key findings demonstrate the potential of this method to provide comprehensive and cost-effective insights compared to traditional approaches like on-site audits and manual surveys, which often face limitations in terms of cost, scalability, and data precision. This research contributes to the existing body of knowledge by offering validated methodologies for technical and survey-based SRI assessments. Implementing the SRI framework promotes technological innovation within the construction sector, offering a strong incentive for integrating cutting-edge smart technologies in buildings.

CASE25_ME_I_10 — Towards Integrated Building Assessment: A Unified Certificate for Energy Performance and Smart Readiness

Theoklitos Klitou[1,2]*, Paris Fokaides[1,2], Sophie Dourlens-Quaranta[3], Cécile Barrère[3], Andrei Vladimir Litiu[4], Paraskevas Koukaras[5], Sara Momi[6]
[1] Frederick University, Nicosia, Cyprus
[2] Euphylia Tech Ltd, Nicosia, Cyprus
[3] R2M Solution France, Roquefort-les-Pins, France
[4] EPB Center, Rotterdam, Netherlands
[5] Centre for Research & Technology Hellas, Marousi, Greece
[6] R2M Solution S.r.l, Pavia, Italy
E-mail: res.kit@frederick.ac.cy

Abstract.
regulations, particularly following the recast Energy Performance of Buildings Directive (EPBD 2024), underscores the necessity of harmonizing parallel certification schemes. In this context, the Smart Readiness Indicator (SRI), designed to assess the capacity of technical building systems to optimize energy use, adapt to occupants' needs, and interact with the grid, is progressively being introduced across Member States. Simultaneously, the Energy Performance Certi□icate (EPC), a long-established tool, continues to evolve towards greater granularity and utility. Despite their complementary scope, these instruments have historically been developed and implemented in isolation. This study presents a unified certification approach developed within the framework of the SmarterEPC project, aiming to visually and functionally integrate EPC and SRI results into a single, modular document. The proposed joint certi□icate consolidates mandatory and optional indicators from both schemes and is fully aligned with the EPBD 2024 and SRI Delegated Regulation requirements. Emphasis is placed on user-centric design principles, modularity for national adaptability, and visual clarity to enhance stakeholder engagement. The work introduces the conceptual design of the joint certificate, elaborating on the standardised metrics, classification schemes, and data visualisation techniques employed to support both compliance and informed decision-making. Through this integration, the joint certificate not only reduces administrative complexity but also provides a holistic view of building performance, facilitating investment, renovation planning, and policy enforcement. The proposed approach reflects a forward-looking shift toward digital, interoperable, and action-oriented assessment tools, ultimately fostering the decarbonisation and digitalisation of the EU building stock.

ME03 - Engineering Innovations in Materials, Manufacturing, Imaging, and Quality Systems

CASE25_ME_E_19 — Advancing Quality and Performance in the Textile Industry: A Sustainability Engineering Review of TQM Practices, ISO 9001 Standards, and Safety Culture Integration

Zohaib Khan[1,2]*, Yusri Bin Yusof[1], Md Fauzi Bin Ahmad[3], Yazid Saif[3], Maznah Iliyas Ahmad[4]
[1] Faculty of Mechanical and Manufacturing Engineering, Universiti Tun Hussein Onn Malaysia, 86400, Parit Raja, Batu Pahat, Malaysia
[2] Department of Mechanical Engineering, The University of Larkano, 77151, Sindh, Pakistan
[3] Faculty of Technology Management & Business, Universiti Tun Hussein Onn Malaysia, 86400, Parit Raja, Batu Pahat, Malaysia
[4] Department of Mechanical Engineering, Politeknik Sultan Azlan Shah, Behrang Stesen, 35950, Perak, Malaysia
*E-mail: aghzohaib03@gmail.com

Abstract.
Total Quality Management (TQM) plays a vital role in improving efficiency, quality and sustainability in the textile industry through ISO 9001 certification, safety culture and supplier relationship management. This review highlights how these integrated practices enhance product consistency, operational performance and compliance with global standards. The study adopts a sustainability engineering perspective, combining qualitative and quantitative insights, showing that strong safety culture boosts morale, ISO 9001 ensures standardization and supplier relations support stable production. It also suggests future integration of AI and IoT to advance quality control and predictive maintenance.

CASE25_ME_I_14 — Effect of FDM Process Parameters on the Mechanical Response of PLA Structures for Orthopedic Applications

Stelios Avraam[1,2], Demetris Photiou[2], Theodoros Leontiou[1], Loucas Papadakis[1]*
[1] Department of Mechanical Engineering, Frederick University, Nicosia, Cyprus
[2] Simlead Ltd, Nicosia, Cyprus
*E-mail: l.papadakis@frederick.ac.cy

Abstract.
The advancement of polymeric materials for orthopedic applications has led to the development of lightweight, adaptable structures that enhance patient-specific solutions. This study investigates the design, fabrication, and mechanical characterization of additively manufactured (AM) polymeric structures using Fused Deposition Modeling (FDM). By optimizing geometric configurations and material properties, these structures offer improved flexibility, energy absorption, and load distribution, making them suitable for orthopedic products and assistive devices. A mechanical testing campaign was conducted to measure the elasticity and strength of FDMed samples under tensile and 3-point-bending. Specific process parameters as nozzle diameter, layer thickness and printing orientation were varied and the resulted elasticity and strength were recorded. The results demonstrated that process parameters influence mechanical response, i.e. elasticity, ductility and strength, in a complicated manner. For this reason, machine learning (ML) was applied to optimize the FDM process parameter selection, aiming in predicting the mechanical response and adapting it according to application needs. By utilizing the aforementioned key process parameters the ML model learns to predict the critical output mechanical properties, i.e. elasticity and strength. Thereupon, feasible process parameter ranges are proposed with the aim to adapt meta-material elasticity, thus, assisting in reducing the reliance on traditional trial-and-error approaches by balancing orthopedic product quality and process efficiency.

CASE25_ME_I_15 — Simulation-driven Design, 3D-Printing and Testing of Metallic Implant Auxetic Structures with Adjusted Stiffness for Improved Bone Integration

Stelios Avraam[1,2]*, Demetris Photiou[2], Ane Miren Mancisidor[3], Alexandros Loizou[4], Angelos Evangelou[4], Theodora Kyratsi[4], Loucas Papadakis[1,5]

[1] Department of Mechanical Engineering, Frederick University, Nicosia, Cyprus

[2] Simlead Ltd, Nicosia, Cyprus

[3] LORTEK, Basque Research and Technology Alliance (BRTA), Ordizia, Spain

[4] Department of Mechanical and Manufacturing Engineering, University of Cyprus

[5] Frederick Research Center, Nicosia, Cyprus

*E-mail: l.papadakis@frederick.ac.cy

Abstract.

The mechanical mismatch between metallic implants and bone tissue remains a critical challenge in orthopedic and biomedical engineering, often leading to stress shielding and bone failure. This study explores the development of mechanically adjusted stiffness of metal-based biomaterials designed to allow implants for optimal load transfer and long-term stability. By leveraging the flexibility offered by additive manufacturing techniques such as laser-based powder bed fusion (L-PBF) and topology optimization, implant structures with tunable mechanical properties that closely match the bone stiffness were designed and engineered. The proposed approach integrates computational modeling and experimental testing to refine lattice structures that improve mechanical compatibility while maintaining structural integrity. The rendered results indicate that strategically designed cellular structures with auxetic behaviour significantly reduce stress shielding, enhancing implant remodeling and longevity. Furthermore, static and fatigue resistance performance is tested for 3D-printed as well as heat-treated auxetic samples under compression loading to ensure reliability for the intended operation. This study highlights the critical role of biomechanical adaptation in next-generation implants, demonstrating how tailored structural designs can mitigate mechanical complications associated with conventional metallic biomaterials. The findings provide a foundation for the future development of smart, load-adaptive implants that enhance patient outcomes by fostering optimized natural bone-implant interactions.

CASE25_ME_I_18 — Efficient Implementation of Stochastic Reconstruction Methods in Emission Tomography

Theodoros Leontiou[1,2]*, Yiannis Parpottas[1,2], Elena Ttofi[3,4], Anna Frixou[5], Efstathios Stiliaris[6], Charalambos Chrysostomou[7], Costas N. Papanicolas[5,8]

[1] Department of Mechanical Engineering, Frederick University, Nicosia, Cyprus

[2] Frederick Research Center, Nicosia, Cyprus

[3] Department of Electrical and Computer Engineering and Informatics, Frederick University, Nicosia, Cyprus

[4] Information Technology Department, German Medical Institute, Limassol, Cyprus

[5] CaSToRC, The Cyprus Institute, Nicosia, Cyprus

[6] Department of Physics, National and Kapodistrian University of Athens, Athens, Greece

[7] ERATOSTHENES Centre of Excellence, Cyprus University of Technology, Limassol, Cyprus

[8] The Cyprus Academy of Sciences, Letters and Arts

*E-mail: t.leontiou@frederick.ac.cy

Abstract.

The inverse problem of emission tomography can be represented as a problem of sampling from a multivariable probability distribution. Stochastic methods are particularly well-suited for this purpose due to their ability to effectively explore high-dimensional parameter spaces, enabling efficient convergence and accurate sampling. These methods are also highly compatible with GPU acceleration, where parallelism enhances the processing of high-resolution tomographic data. In this work, we demonstrate the efficiency and applicability of a stochastic reconstruction framework in the context of Single Photon Emission Computed Tomography (SPECT). Our approach incorporates attenuation correction using Monte Carlo simulations that exploit patient-specific CT scans, allowing for customization of the reconstruction process to individual anatomy. This personalization has the potential to reduce unnecessary radiation exposure and improve diagnostic efficiency—key goals in the pursuit of more sustainable healthcare technologies. We demonstrate this stochastic implementation using a hardware anthropomorphic phantom, focusing on the detection and quantification of thyroid remnants. The framework contributes to sustainable medical imaging by enabling targeted, patient-specific diagnostics and more efficient use of computational and clinical resources.

CASE25_ME_I_25 — Point Spread Function Reconstruction in 18F PET/CT myocardial perfusion studies

Panayiotis Hadjitheodorou[1,2], Irene Polycarpou[3]*, Georgios Soultanidis[4], Sotiris Panayi[5], Yiannis Parpottas[5], Alexis Vrahimis[1]

[1] Department of Nuclear Medicine, German Oncology Centre, Limassol, Cyprus

[2] School of Medicine, European University Cyprus, Nicosia, Cyprus

[3] Department of Health Sciences, European University Cyprus, Nicosia, Cyprus

[4] BioMedical Engineering and Imaging Institute, Mount Sinai School of Medicine, New York

[5] Frederick University, Nicosia, Cyprus

*E-mail: i.polycarpou@euc.ac.cy

Abstract.

PET myocardial perfusion imaging (MPI) is increasingly utilized in the diagnosis of obstructive coronary artery disease and evaluation of the extent and severity of myocardial ischemia. However, blurring caused by the partial volume effect and patient motion may deteriorate the image quality thereby distorting the interpretation of MPI studies. Point spread function (PSF) reconstruction algorithms have been successfully applied on PET to reduce blurring. This study aimed to evaluate the application of a commercially available PSF reconstruction algorithm, SharpIR, on cardiac imaging and its potential benefit in reducing image blurring. Experimental datasets from an anthropomorphic phantom with and without motion have been acquired with a clinical PET/CT scanner for variable scan times. Two reconstruction schemes were applied: OSEM and SharpIR. The results demonstrated that the introduction of PSF in the reconstruction improved quantification of cardiac uptake and yielded to a more accurate estimation of the wall thickness, indicating its clinical potential especially for non-gated acquisitions/data. No significant differences were reported in the SharpIR images with even 50% reduction of the scan time compared to the OSEM images with full time acquisition.

CASE25_ME_I_26 — Experimental and simulation approaches to strength and quality enhancement of composite sandwich structures in leisure waters skis

Dr. Antonios Lontos[1]*, Dr. Andreas Gregoriou[1]
[1] Department of Mechanical Engineering, Frederick University, Nicosia, Cyprus
*E-mail: eng.la@frederick.ac.cy

Abstract.
Water skiing is a popular water sport that combines excitement, athleticism, and skill. In this activity, a person is towed behind a boat while balancing on skis designed specifically for gliding across the water's surface. Water skiing has evolved into various forms, including slalom skiing, trick skiing, and jump skiing, each requiring specialized equipment and techniques. The performance of water skis is highly dependent on their construction materials (such as composite materials with carbon fiber and epoxy resins) and design. These materials offer superior stiffness, strength, and durability, enabling manufacturers to create products that enhance the skier's performance and experience. The shape and layout of water skis significantly influence the handling characteristics, stability, and speed during skiing. Optimizing the stiffness through innovative configurations can improve responsiveness to the skier's movements, allowing for tighter turns and better control during high-speed maneuvers. As the sport continues to grow, water ski manufacturers are increasingly focusing on research and development to create cutting-edge products that meet the demands of both recreational and competitive skiers. By exploring various material combinations and testing methodologies, manufacturers seek to push the boundaries of performance, ultimately enhancing the appeal and safety of water skiing as a thrilling sport enjoyed by many. The present study investigates the overall stiffness of two distinct carbon fiber configurations utilized by a water ski manufacturer in Cyprus through a series of three meticulously designed load experiments. Following ASTM standards, both bending and edgewise compression tests were conducted to evaluate the mechanical properties of the used composite materials and manufacturing process. Additionally, the adhesion of carbon fiber sheets over a PVC foam core were explored using a tailored methodology aimed at drawing significant conclusions regarding structural integrity. The comparative analysis from the bending and edgewise compression tests revealed that, one the specimens exhibiting superior stiffness. The present findings will play a crucial role in shaping the future designs of the manufacturer’s water ski products, ensuring enhanced performance and durability in the competitive market.

ME04 - Sustainability and Circular Innovation Across Built and Natural Environments

CASE25_ME_E_02 — BIM-LCA data fidelity for building-passport workflows: IFC export vs drawing take-off

Manvydas Mikulėnas[1], Lina Šedukytė[1]

[1] Faculty of Civil Engineering and Architecture, Kaunas University of Technology, Kaunas, Lithuania

*E-mail: manvydas.mikulenas@ktu.edu, lina.sedukyte@ktu.lt

Abstract.

While BIM-LCA plugins allow faster life cycle assessment (LCA) workflows, 2024 Energy Performance of Buildings Directive (EPBD) and upcoming assurance frameworks begin demanding auditable workflows - here - Digital Building Logbooks (DBLs), leading to potential gap between speed and accuracy. This study benchmarks two BIMto-LCA routes on a 3794 m2 science building in Kaunas, Lithuania: IFC → OneClickLCA and drawing take-off (PDF → LCAbyg) workflows. Both use sector-average datasets and cover modules A1-D over a reference study period, here, 50 years. The IFC export dropped curtain-wall and HVAC objects, resulting in 30% greater whole-life kgCO2eq; restoring elements cut the gap to 8 %. Changing only the electricity grid setting in LCAbyg from static mix to progressive mix shifted the GWP by 46 %. Module D credits ranged from -600 t to -146 t CO2e because OneClick defaults to downcycling, whereas LCAbyg passes the EPD module D value and rescales it with the grid factor. These swings exposed the impact of the lack of metadata from exported BIM model into IFC. Geometry checks at export/import and additional DBL tags (electricity factor and scenario type, for module D transparency) could let plugin workflows reach 10 % deviation with manual take-off at LOD 300 - meeting EPBD 2024 upcoming requirements - while avoiding rework.

CASE25_ME_E_06 — Disassembly of building envelopes in Greece: Early insights into unlocking the potential of circular design and construction practices

Christina Mykoniou[1]*, Konstantinos Zamanidis[2], Kleoniki Axarli[1], Dimosthenis Ioannidis[2], Konstantinos Sakanntamis[3]

[1] School of Architecture, Faculty of Engineering, Aristotle University of Thessaloniki, Thessaloniki, Greece

[2] Information Technologies Institute, Centre for Research and Technology Hellas, Thessaloniki, Greece

[3] Department of Statistics, School of Economic Sciences, University of Western Macedonia, Grevena, Greece

*E-mail: cmykoni@arch.auth.gr

Abstract.

The need for sustainable construction techniques in the building sector has become urgent within the framework of the European Green Deal and the policies for circular economy introduced by the European Union. Conventional structure design models are inherently linked to depletion of natural resources, significant energy consumption and an intensive carbon footprint. Life cycle analysis of the built environment underscores the necessity to rethink the practices of designing and decommissioning buildings to achieve the climate neutrality goals. In this regard, the Design for Disassembly (DfD) approach emerges as a forward-thinking perspective, focusing on waste reduction and promoting the reuse of construction materials and components from the initial design stages. Integrating DfD principles requires a holistic strategy that considers various dimensions. The lack of a dedicated legislative framework, as is currently the case in Greece, presents additional challenges for its acceptance by the professional community. This study explores the feasibility of DfD deployment within the national context, utilizing quantification techniques to assess qualitative data. A critical comparative review of the related literature was conducted to outline the research pathway. The methodology encompasses the synthesis and distribution of a survey questionnaire targeting an adequate number of relevant stakeholders, namely architects and construction professionals. The collected data provides preliminary insights into the awareness, acceptance and practical application of DfD principles in the Greek context. The outcomes underline the potential along with the limitations associated with the examined design approach and offer early-stage feedback that could influence future research directions. Key factors under examination include material selection, layering and separation of construction elements, standardization and component connectivity, alongside spatial planning considerations and seismic resilience. By evaluating experts' perceptions on DfD, this study contributes to the broader conversation on sustainable building practices and highlights opportunities for further development and adoption of the design mindset.

CASE25_ME_E_17 — Resilient Water Management in Smart Buildings: Insights from the COVID-19 Pandemic

Konstantinos Chatzikonstantinidis[1]*, Effrosyni Giama[1], Georgios Chantzis[1], Anastasia Zafeiriou[1], Paris A. Fokaides[2,3], Agis M. Papadopoulos[1]

[1] Process Equipment Design Laboratory, School of Mechanical Engineering, Aristotle University of Thessaloniki, 54124, Thessaloniki, Greece

[2] School of Engineering, Frederick University, 7, Frederickou Street, 1036, Nicosia, Cyprus

[3] Faculty of Civil Engineering and Architecture, Kaunas University of Technology, 48, Studentu Street, 51367, Kaunas, Lithuania

*E-mail: kchatziko@auth.gr

Abstract.

The COVID-19 pandemic presented unprecedented challenges for water management systems worldwide, amplifying the demand for resilience, adaptability, and sustainability. This study investigates the multifaceted impacts of the pandemic on water consumption patterns and resource management strategies, focusing on a case study of a residential complex in Larnaca, Cyprus. Data spanning pre-pandemic, lockdown, and post-lockdown periods revealed a 40% surge in daily water consumption during the lockdown, driven by heightened hygiene practices, increased domestic activities, and prolonged home confinement. The findings underscore the critical role of smart technologies, such as IoTenabled sensors and predictive analytics, in optimizing water use and ensuring resource sustainability. Furthermore, the study highlights the socio-economic disparities in access to clean water, exacerbated by the pandemic, and the need for equitable and inclusive governance frameworks. Strategies such as real-time monitoring, water recycling, and community engagement emerged as essential tools for navigating crises. The research emphasizes the importance of integrating water management with broader sustainability goals, including renewable energy systems and urban planning. By combining innovative technologies with sustainable practices, this study provides actionable insights for policymakers, water utilities, and stakeholders, offering a roadmap toward robust and adaptive water management systems in an evolving global landscape. Keywords: Water Management, COVID-19 Pandemic, Buildings, Smart Technologies, Resilience

CASE25_ME_I_01 — Advancing Green University Campuses: Challenges, Best Practices, and the Role of Environmental Management Systems

Evi Demetriou[1]*, Christos Vatsistas[2], Olga Anne[3], Zvjezdan Penezic[4], Paris Fokaides[1]
[1] Mechanical Engineering, Frederick University, Nicosia, Cyprus
[2] Department of Natural Resources Management and Agricultural Engineering, Agricultural University of Athens, Athens, Greece
[3] Department of Engineering of Marine Technology and Natural Sciences, Klaipeda University, Klaipeda, Lithuania
[4] Department of Psychology, University of Zadar, Zadar, Croatia
*E-mail: res.de@frederick.ac.cy

Abstract.
Universities around the world are increasingly striving to become "green campuses" by integrating environmentally sustainable practices into their operational and academic frameworks. Although the term is not formally defined, it has gained traction as a strategic vision for institutions aiming to demonstrate environmental responsibility. This paper investigates the core components of sustainable campus operations and proposes a unified framework that consolidates effective practices drawn from multiple case study universities. The objective is to move beyond fragmented efforts by identifying common strategies and integrating them into a comprehensive action plan, offering a novel approach to the green campus concept.

CASE25_ME_I_02 — Navigating the Bio-economy Landscape: Crafting Sustainable and Circular Futures for Underrepresented Southern European Regions

Kyriaki Koumenidou[1], Evi Demetriou[1], Phoebe Vayanou[2], Paris Fokaides[1]*
[1] School of Engineering and Applied Sciences, Frederick University, 7, Y. Frederickou Str., 1036 Nicosia, Cyprus
[2] Nature Conservation Unit, School of Engineering and Applied Sciences, Frederick University, 7, Y. Frederickou Str., 1036 Nicosia, Cyprus
*E-mail: p.fokaides@frederick.ac.cy

Abstract.
As Europe transitions toward a greener future, the bio-economy plays a pivotal role in driving sustainability. However, many regions—particularly in Southern Europe— remain underrepresented in policy support. This paper explores the bio-economy policy landscape in these regions through a SWOT analysis, examining the economic, environmental, and social impacts. The analysis identifies key gaps and opportunities, providing insights for the development of region-specific policy recommendations that align with EU strategies such as the European Green Deal, the Bioeconomy Strategy, and the Circular Economy Action Plan. The outcomes of this study aim to serve as a sustainable practice, offering tools to address current environmental challenges. A central component of the study is the development of a circularity monitoring system, which defines key performance indicators (KPIs) to track the sustainability of bio-based sectors. The toolkit, a user-friendly digital platform, will integrate these recommendations alongside relevant data, methodologies, and KPIs to help stakeholders assess and enhance the sustainability of bio-based practices in Southern Europe. Serving as a key resource for policymakers and industry professionals, the toolkit will guide decision-making and support the transition to a more sustainable and circular bio-economy. Furthermore, it will not only foster sustainable practices across sectors but also guide the transition toward more energy-efficient and sustainable energy solutions. A stakeholder forum will be organized to present the findings and engage policymakers at local, regional, and EU levels, fostering informed decision-making and advancing sustainability efforts in the bio-economy.

CASE25_ME_I_16 — Advancing Sustainable Aquaculture in Cyprus: Challenges, Innovations, and Future Perspectives

Michalis Menicou[1]*, Marios Charalambides[2], George Triantaphyllidis[3], Charalambous Stefanos[4]

[1] Department of Mechanical Engineering, Frederick University, Nicosia, Cyprus

[2] Department of Business Administration, Center of Sciences, Frederick University, Nicosia, Cyprus

[3] Hellenic Centre for Marine Research, Institute of Oceanography, 46.7 km Athens-Sounio Avenue, PO Box 712, GR 19013 Anavyssos, Attica, Greece

[4] T.C. Geomatic Technologies Ltd., 1095, Nicosia, Cyprus

*E-mail: m.menicou@frederick.ac.cy

Abstract.

Aquaculture is a key sector for Cyprus, contributing significantly to food security and economic growth. However, its expansion is challenged by environmental concerns, climate change, resource management issues, and the restricted marine environment available for operations, including limited coastal areas and suitable sea depths for aquaculture. This study explores the current state of aquaculture in Cyprus, describing key species farmed, economic impact, and regulatory frameworks. We examine sustainability challenges, including habitat degradation and market pressures, while presenting technological innovations such as recirculating aquaculture systems, AI-driven monitoring, and alternative fish feeds. Policy frameworks, stakeholder collaboration, and potential for offshore aquaculture are also analysed, providing a roadmap for sustainable growth. By integrating advanced technologies, policy reforms, and international collaborations, this research proposes strategic pathways to ensure a resilient and eco-friendly aquaculture sector in Cyprus.

ME05 - Resilient, and Accessible Buildings through Digital Innovation

CASE25_ME_E_03 — Evaluation of Building Energy Model for Space Cooling Cooling

Wiktoria Łokczewska[1]*, Tomasz Cholewa[1]
[1] Faculty of Environmental Engineering and Energy, Lublin University of Technology, Lublin, Poland
*E-mail: s99258@pollub.edu.pl

Abstract.
The building sector is one of the largest energy consumers, with the rising demand for air conditioning driven by increasing global temperatures, expanding urban areas, and higher expectations for indoor thermal comfort. This study presents a methodology for estimating the impact of external factors, such as outdoor temperature, solar insolation, and wind speed, on air conditioning energy consumption. A universal calculation algorithm has been developed to create an accurate building model that accounts for actual operating conditions. By incorporating corrections for meteorological variables, the model enables estimation of cooling power consumption. The findings can contribute to optimizing air conditioning systems and improving energy efficiency in buildings.

CASE25_ME_E_13 — On the application of forecast control of heating in University building Cooling

Wiktoria Łokczewska[1];Tomasz Cholewa[1]*
[1]Faculty of Environmental Engineering and Energy, Lublin University of Technology, Lublin, Poland
*E-mail: t.cholewa@pollub.pl

Abstract.
Building sector in EU consumes around 43% of final energy and around 66% of this is used for heating. That is why, measures to increase energy efficiency, which are easy to implement and of low pay back time, are very important. One of such possibilities is integration of innovative forecast control into existing heating system controlled by weather-based system. This paper shows good practices from exploitation of such a system in existing University building in Poland. The characteristic parameters of heat supply are analysed based on field research, which will support and explain the level of energy savings obtained thanks to application of such a control system in analysed building. Future research directions in this field are also presented.

CASE25_ME_I_05 — A Data-Driven Framework for Operational Energy Performance Certification Aligned with Directive (EU) 2024/1275

Christos Kythreotis[1]*, Pablo Carnero Melero[2], Angeliki Veliskaki[3], Stavros Koltsios[3], Paris A. Fokaides[1]

[1] Department of Mechanical Engineering, Frederick University, Nicosia, Cyprus

[2] REHVA – Federation of European Heating, Ventilation and Air Conditioning Associations, Brussels, Belgium

[3] Centre for Research and Technology Hellas (CERTH), Thermi, Thessaloniki, Greece

*E-mail: res.ckt@frederick.ac.cy

Abstract.

The upcoming recast of the Energy Performance of Buildings Directive (Directive 2024/1275) requires that future Energy Performance Certificates (EPCs) incorporate comprehensive life-cycle carbon metrics. Specifically, EPCs must disclose the global warming potential (GWP) across the building's entire life-cycle and integrate full life-cycle assessment (LCA) results into energy ratings. Despite this requirement, the European Union currently lacks established benchmarks and consistent methodologies for effectively incorporating LCA outcomes and real-world operational data into building energy certificates. To address this methodological gap, a new performance-based benchmarking approach has been developed, utilizing advanced digital tools enhanced by artificial intelligence. This platform leverages continuous monitoring through Internet of Things (IoT) technologies, digital twin models, and predictive analytics to effectively integrate operational energy data with comprehensive LCA calculations. By combining these elements, it bridges the gap between traditional static asset ratings and actual building operational performance. This study outlines the conceptual framework of the newly developed benchmarking methodology, detailing the mechanisms by which these digital tools establish robust metrics for operational energy efficiency, embodied carbon, and other relevant operational parameters. Aligned with the new EPBD requirements, this approach provides a practical strategy to evolve current EPCs from static assessments towards dynamic, life-cycle-oriented evaluations. Furthermore, it demonstrates how next-generation EPC systems can effectively incorporate real-time IoT data, advanced simulation models, and AI-driven analytics, thus meeting emerging policy directives and significantly improving the accuracy, reliability, and utility of building energy performance certifications.

CASE25_ME_I_07 — Enhancing Accessibility in the Built Environment Using IoT-Enabled Smart Sensors.

Eleni Apostolidou[1]*, Paris Fokaides[1], Constantinos Tatas[1], Victoras Kassianides[1], Raquel Ortega Martínez[2], Helen Chalkia[3], Panagiota Chatzipanagiotidou[3], Dimosthenis Ioannidis[3], Napoleon Bezas[3], Ioannis Koskinas[3], Dimitris Tziplopoylos[3]

[1] School of Engineering, Frederick University, Cyprus

[2] Asociación Empresarial De Investigación Centro Tecnologico Del Mueble Y La Madera De La Región De Murcia, Murcia

[3] Centre of Research and Technology Hellas, Greece

*E-mail: res.aa@frederick.ac.cy, p.fokaides@frederick.ac.cy, con.tat@frederick.ac.cy, ta.eng.kvf@frederick.ac.cy, rortega@cetem.es, hchalkia@certh.gr, phatzip@iti.gr, d.ioannidi@iti.gr, bezas@iti.gr, koskis@iti.gr, dimitpio@iti.gr

Abstract

The built environment profoundly impacts daily life, particularly for individuals with disabilities who often face barriers to safe and independent navigation. This review explores how digital twin technologies, combined with IoT-enabled smart sensors, can enhance accessibility in smart buildings and create more inclusive spaces.

The objective is to investigate current and emerging ICT tools—such as sensors, AI, and real-time data processing—and assess their ability to support individuals with physical or sensory impairments. The study addresses a critical gap in the literature: the limited application of these technologies in public buildings, as most solutions are focused on home environments. The novelty lies in the shift toward leveraging digital twins and smart technologies for real-time navigation, hazard detection, and environmental feedback, especially in public and semi-public spaces. As a methodology, a structured literature review is conducted, supported by the use of Biblioshiny to perform bibliometric analysis and identify research trends and gaps. Technologies are further classified thematically by disability type, context, and functionality. The results are expected to provide actionable insights into how digital solutions can foster inclusive, user-centered environments. This review offers a short and organized synthesis of technological approaches to accessibility.

CASE25_ME_I_08 — Comparative Assessment of Smart Ready Technologies Using Economic and Technological Metrics

Turkay Ersener[1]*, Paris A. Fokaides[1], Paraskevas Koukaras[2], Fatemeh Asgharzadeh[3], Antonio Luparelli[4], Giuseppe Rocco Rana[5], Giuseppe Mastandrea[5]

[1] Department of Mechanical Engineering, Frederick University, Nicosia, Cyprus

[2] Ethniko Kentro Erevnas Kai Technologikis Anaptyxis, Thessaloniki, Greece

[3] Demo Consultants BV, Delft, Netherlands

[4] Centro Di Ricerche Europeo Di Tecnologie Design E Materiali, Brindisi, Italy

[5] Energy@Work Societa' Cooperativa A R.L., Bari, Italy

*E-mail: res.ert@frederick.ac.cy

Abstract

The implementation of Smart Readiness Technologies (SRTs) across the European Union remains uneven, hindered not only by technical and regulatory variability but also by a lack of standardized financial viability metrics. This study introduces a dual-indicator framework combining the Risk-Adjusted Discount Rate (RADR) and the Return on Smart Investment (RoSI) to assess the financial feasibility of SRT deployment. RADR integrates country-specific risk premiums using macroeconomic inputs such as sovereign bond yields, energy price volatility (Eurostat), and green finance accessibility (EU Green Bond data). RoSI captures net financial performance over a 10-year device lifecycle, incorporating installation, operation, and maintenance costs against projected energy savings. The analysis applies this framework to six EU countries—Austria, Greece, Cyprus, Spain, Italy, and the Netherlands—revealing a clear relationship between national market risk and the investment viability of smart technologies. Devices such as the RVL482 Heating Controller maintain strong RoSI under both standard and riskadjusted conditions, while others (e.g., ultrasonic heat meters) consistently underperform. High RADR values in Greece and Cyprus correspond to larger RoSI reductions, suggesting potential barriers to private-sector uptake. Conversely, countries with mature green finance ecosystems and stable energy markets exhibit greater technology viability even without subsidies. These findings reinforce the importance of integrating financial readiness indicators into Smart Readiness Indicator (SRI) frameworks to inform incentive design, investment prioritization, and policy planning.

CASE25_ME_I_09 — Reviewing Resilience Enhancement Solutions for the Built Environment under Climate Stressors

Anastasios Petrou[1], Artemis Georgiou[1], Styliani Georgiou[1], Kyriaki Koumenidou[1], Constantina Kyrakou[1], Paris A. Fokaides[1]*

[1] SERG, Frederick University, Nicosia, Cyprus

*E-mail: p.fokaides@frederick.ac.cy

Abstract

Mediterranean cities are increasingly exposed to extreme heat events, amplifying urban heat island effects and compromising outdoor thermal comfort. This study investigates the microclimatic performance of a representative high-density urban district in Barcelona, characterized by a modernist grid layout with limited vegetation and high impervious surface coverage. Using the ENVI-met simulation tool, seasonal air temperature distributions were modeled at pedestrian level under both normal and extreme weather conditions. Results reveal a significant temperature increase during heatwaves, with average grid temperatures in July rising by over 8 °C compared to normal conditions. Four passive cooling strategies—green roofs, green facades, cool pavements, and cool roads—were evaluated under extreme conditions. Green roofs and cool pavements showed the highest cooling potential in summer, while green facades were more effective in milder seasons. The spatial analysis identified critical thermal hotspots, such as exposed intersections and interior courtyards, as priority areas for intervention. The findings demonstrate the necessity of context-specific, seasonally adaptive solutions to mitigate urban overheating. This work, developed in the framework of the CLIMRES project, contributes to datadriven urban resilience planning and provides actionable insights for architects, urban planners, and policymakers aiming to enhance thermal comfort in climate-vulnerable districts. Keywords: Urban heat island; Climate resilience; Passive cooling; Thermal comfort; Mediterranean cities

ME06 - Sustainable Transport and Energy Innovations

CASE25_ME_E_12 — Innovative Framework to Sustainability Assessment and Sustainable Design in Aviation

Thomas Kalampoukas[1], Angelos Filippatos[1]*, Dionysios Markatos[1], Spiros Pantelakis[1]
[1] Department of Mechanical Engineering & Aeronautics, University of Patras, Patras, Greece
*E-mail: angelos.filippatos@upatras.gr

Abstract.
The aviation and maritime industries faces increasing pressure to reduce its environmental impact, making sustainability-driven design a critical approach to addressing this challenge. Over the past years, a series of studies by the authors have explored innovative methods for sustainability assessment and sustainable design in aviation, focusing on material selection, multi-criteria decision-making (MCDM), and the integration of sustainability into the early design stages of aircraft components. In a study of the authors , the role of material choices in aviation sustainability is examined, presenting a decision-support tool that integrates ecological, economic, and circular economy dimensions to identify materials aligned with sustainability goals. Another study of the authors compares different MCDM methods and normalization techniques, highlighting their influence on the robustness and reliability of sustainability indices in aviation. In, a holistic MCDM-based approach is implemented to assess and compare aircraft under the prism of sustainable aviation. The study balances technological, economic, and ecological sustainability, including circular economy aspects. A combination of the analytic hierarchy process (AHP) and a weighted addition model is used to evaluate and rank aircraft with novel fuel/propulsion technologies, exploring the impact of different sustainability priorities on the ranking. A sustainability-driven design process for aircraft components is proposed in , incorporating technological, environmental, economic, and circular economy criteria into the early stages of design. This methodology is validated through a case study using a composite plate and an aviation demonstrator. Finally, a shift from eco-driven to sustainability-driven design is introduced, emphasizing the integration of social impact and circularity alongside traditional sustainability pillars. A sustainability index is developed to optimize design alternatives. Together, these studies offer a comprehensive approach to sustainability assessment and sustainable design practices aviation. Results will be highlighted, providing valuable insights for advancing engineering practices and contributing to more sustainable aviation solutions. Following this stage, the perception of sustainability as highlighted before is transferred to the maritime industry, as continuous research efforts of the authors to apply cross-sectoral characteristics to the developed framework.

CASE25_ME_I_13 — The role of Natural Gas Vehicles in the energy transition era

Eleni Himona, Andreas Poullikkas*
School of Engineering, Frederick University, 7 Frederickou Street, 1036 Nicosia, Cyprus
*E-mail: a.poullikkas@frederick.ac.cy

Abstract.
The urgent need for decarbonization in the transport sector has positioned Natural Gas Vehicles (NGVs) as a critical transitional technology in the global energy transition. This study presents a comprehensive analysis of NGV feasibility and sustainability through well-to-wheel emissions assessment, comparing compressed natural gas (CNG) and liquefied natural gas (LNG) vehicles against conventional diesel and petrol vehicles, as well as electric and hydrogen fuel cell alternatives. The research demonstrates that NGVs achieve approximately 25% reduction in CO2 emissions compared to conventional vehicles on a well-towheel basis, while offering significant economic advantages through lower fuel costs and operational expenses. With 23 million NGVs currently operating worldwide, the technology shows particular promise in regions with established natural gas infrastructure, where the optimal refueling station-to-vehicle ratio of 1:600 to 1:1000 can be maintained. However, the study reveals that battery electric vehicles (BEVs) outperform NGVs by 60-100 gCO2/km in lifecycle emissions, highlighting the importance of considering NGVs as an intermediate solution rather than a long-term decarbonization strategy. The Cyprus case study reveals significant potential for NGV implementation, particularly given that road transport accounts for 21.2% of national greenhouse gas emissions, with 48.6% of vehicle registrations being petrol-powered as of 2024. Despite the complete absence of CNG/LNG refueling infrastructure and recent natural gas discoveries in Cyprus' Exclusive Economic Zone, strategic pilot programs focusing on public transport could provide a pathway for NGV adoption. The study recommends targeted policy interventions including €3,000-5,000 purchase subsidies and €4- 6 million infrastructure investments to establish viable NGV networks while ensuring future compatibility with emerging clean fuel technologies.

CASE25_ME_I_17 — Hydrogen-Powered UAVs: A Sustainable and Efficient Solution for Aerial Surveillance and Data Collection

Michalis Menicou[1]*, Giorgos Karagiorgis[1,2], Christodoulos Christodoulou[1,2]
[1] Department of Mechanical Engineering, Frederick University, Nicosia, Cyprus
[2] Hystore Tech Ltd, 30 Spyrou Kyprianou, Ergates Industrial Area, 2643 Nicosia, Cyprus
*E-mail: m.menicou@frederick.ac.cy

Abstract.
Hydrogen-powered unmanned aerial vehicles (UAVs) present a sustainable and efficient alternative to battery and fossil fuel-powered drones for aerial surveillance and data collection. This paper explores the advantages of hydrogen fuel cell technology in UAV applications, emphasizing its superior endurance, extended range, reduced refuelling time, and lower operational costs. The HY-FLY VTOL UAV, a lightweight hydrogen-powered drone with six-hour flight endurance and a 440 km range, is introduced as a case study, demonstrating its technical and economic feasibility. Comparisons with battery- and petrol-powered UAVs emphasise the environmental and operational benefits of hydrogen fuel cells. The paper also discusses applications in infrastructure monitoring, security, environmental research, and disaster response, along with the economic viability of hydrogen UAVs in an evolving market. Finally, challenges such as hydrogen infrastructure, public perception, and regulatory considerations are examined, providing insights into future advancements and policy recommendations for broader adoption of hydrogen-powered UAV technology.

CASE25_ME_I_19 — Modelling of advanced biofuels production and utilisation in internal combustion engines

Charalambos Chasos[1]*
[1]Mechanical Engineering Department, Frederick University, Nicosia, Cyprus
*E-mail: c.chasos@frederick.ac.cy

Abstract.
The aim of the present research work is to address the characterisation of biomass feedstocks and the modelling of advanced biofuels production, as well as examine advanced biofuels' adaptation in internal combustion engines, as a measure to reducing carbon dioxide emissions. The first objective is to survey the available biomass feedstocks for large scale use in biorefinery chemical/thermal processes conversion for advanced biofuels production. The second objective is to review the candidate biomass feedstock chemical components and characteristics. The final objective is to assess the combustion characteristics and the produced emissions from internal combustion engines using pure or blends of advanced biofuels, based on analysis. The methodology employed includes the model of thermodynamics and thermochemistry properties for analysis of feedstock composition, the modelling framework of the chemical pathways in the biorefinery processes for advanced biofuel production, and the mass conservation of air/fuel mixture and emissions production in ICE. Two test biomass feedstocks are examined, namely wood chips and maize residue, for which available published data is collected and analysed for advanced biofuels production. For the ICE emissions analysis, published experimental data for hydrogenated vegetable oil based biofuels and biomass-based advanced biofuels is utilised, and the produced levels of carbon dioxide emissions are estimated. From the present research, findings for the primary intermediate chemical components and composition, pertinent requirements for catalytic treatment, as well as upgrading of chemical compounds for derived biofuels in order to meet the ICE fuel quality are discussed. Recommendations for biomass feedstock quality and a discussion of uncertainties in feedstock composition are provided. It is envisaged that the adaptation of biomass feedstock with selected biorefinery processes will produce advanced biofuels, which will contribute in reduced carbon dioxide emissions and a sustainable transportation.

CASE25_ME_I_20 — Fuel Savings and Reduction of Exhaust Gas Emissions of Existing ICEs by Application of Hydrogen Technologies

Christina Ch. Christodoulou[1,2], Christodoulos N. Christodoulou[1,2], George Karagiorgis[1,2], Michalis Menicou[1]

[1] Frederick University, Nicosia, Cyprus

[2] Hystore Tech Ltd., Nicosia, Cyprus

*E-mail: st015568@stu.frederick.ac.cy

Abstract.

The transition period from an oil-dependent economy to a hydrogendriven economy is expected to progress over the coming decades, with full realization anticipated by 2050. However, during this transition phase, internal combustion engine (ICE) vehicles and ships powered by fossil fuels (diesel, gasoline or natural gas) will continue to operate extensively. Given the cost of fleet replacement, it will not be feasible to completely substitute existing technologies with cleaner alternatives, such as green fuels (Hydrogen, ammonia, bio-diesel, hydrogenated oils), e-fuels (e-Methane, e-Methanol) or swich to a fully electric or hydrogen fuel cell electric power machines. Therefore, immediate interventions are essential to mitigate their environmental impact regarding fuel savings and less exhaust gas emissions (CO2, CO, NOx and Particulates). One promising approach involves enhancing the burning efficiency of existing ICE with the introduction of hydrogen-rich HHO gas (H2+½O2), produced via waterelectrolysis. This paper presents the construction of an optimally designed of a Dry-Cell HHO generator and the results by its application on a diesel truck achieving up to 25% fuel savings and more than 20% reduction of the exhaust gas emissions. Such an application can potentially be used in Buses, Heavy Trucks and in Maritime applications (Ships etc.) with extensive economic benefits, such as fuel savings and environmental benefits including the substantial reduction of exhaust gas emissions

CASE25_ME_I_21 — Demonstration of a Prototype Unit Producing Green Hydrogen, Heat and Alumina by Catalytic Water Decomposition With Recycle Aluminum Metals

Christina Ch. Christodoulou[1,2], Demetris Hadjipetrou[1,2], Christodoulos N. Christodoulou[1,2], George Karagiorgis[1,2], Michalis Menicou[2]

[1] Hystore Tech Ltd, 31 Spyrou Kyprianou Street, Ergates Industrial Area, 2643 Nicosia, Cyprus

[2] Mechanical Engineering, Frederick University, Nicosia, Cyprus

*E-mail: st015456@stu.frederick.ac.cy

Abstract.

Hydrogen gas is the cleanest fuel for electricity production by using H2/Fuel Cells as well as for other applications. The objective of the present study is the greening of circular economy by innovative transformation of reuse of recycled Aluminum into green H2 gas (potentially to be used for electricity production), thermal energy and other value-added by-products, such as Aluminum Hydroxide (Al(OH)3) powder for the Aluminum production companies and/or for other uses such as, polishing pastes, abrasive detergents, abrasive particles for water jets cutting, etc. Specifically, Hystore Tech Ltd, a leading technology Cypriot SME, contacted different studies in order to investigate the behavior of different kind of recycled Aluminum metals such as, Shavings (Chips), Cans (Flatten/Cut) and Slabs (Chunks) in terms of producing Green H2 by catalytic decomposition of water in the presence of NaOH at different concentrations. The ultimate goal of the present study is the design, construction, operation and demonstration of a final Prototype Unit utilizing recycled Aluminum reaching TRL6. The design capacity of the Prototype Unit is expected to be about 50kg of Al metal per day. Experiments performed at different bath-temperatures showed that the H2 production rate is higher for higher temperatures, as expected. Also, the H2 production rate is higher as the NaOH wt% concentration increases. At the same time, high NaOH wt% concentrations favor the initially produced NaAl(OH)4 to remain in solution, whereas for low NaOH wt% concentrations the reaction favors the further hydrolysis of NaAl(OH)4 into Al(OH)3 precipitates and regenerated NaOH catalyst. The overall water decomposition with Al reaction is exothermic exhibiting an enthalpy of the reaction of -415 kJ/moleAl, indicating that as the reaction progresses, the H2 production rate is expected to rapidly increase. Future demonstration experiments on the final prototype unit will take into account the expected heat-production and efficiently store the heat in the form of useful hot water. The use of an experimental prototype unit (10-50g of recycled Aluminum) revealed that the H2 production rates are higher when using Aluminum Shavings, Cans and Slabs, respectively, due to their higher specific area exposed to the water solution of NaOH. Experiments performed by using the experimental prototype unit revealed that it is possible to produce nearly the theoretical amount of 1246 NLH2 ±10% (0.112 kgH2) per kg of recycled Aluminum depending on its purity and taking into account the experimental error involved.

CASE25_ME_I_27 — Crashworthy capability of roadside guardrail systems after electric vehicle impacts

Adonis Vasiliou[1]*, Prof. George Demosthenous[2]
[1] Department of Mechanical Engineering, Frederick University, Yianni Frederickou 7, Nicosia, Cyprus
[2] Department of Mechanical Engineering, Frederick University, Yianni Frederickou 7, Nicosia, Cyprus
*E-mail: a.vasileiou@frederick.ac.cy

Abstract.
Roadside guardrail systems have evolved continuously to protect car occupants, though the sudden introduction of heavier electric vehicles is pushing the boundaries of existing design. This literature review considers compatibility of contemporary guardrails with the novel electric vehicles under the context of the EN1317 standard. The key engineering issues presented are the increased mass and changed weight distribution of EVs as well as their impact on guardrail performance. Documented weaknesses of current barrier systems in resisting high force impacts of EVs are presented. Finite Element Analysis methods have also become central in analyzing and optimizing guardrail systems, with sustainability as well as smart infrastructure concerns being added in newer solutions. This review outlines how advancements in testing protocols as well as standards , like EN1317, are being compelled by heavier, high energy vehicles, with the aim of ensuring safety of roads keeps pace with vehicular advancements.