

Innovative Renewable Energy

Series Editor: Ali Sayigh

Ali Sayigh

Antonella Trombadore

Gisella Calcagno *Editors*

Getting to Zero - Beyond Energy Transition Towards Carbon-Neutral Mediterranean Cities

Selected Papers from the World
Renewable Energy Congress Med Green
Forum 2024



 Springer

Innovative Renewable Energy

Series Editor

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Brighton, UK

The primary objective of the Innovative Renewable Energy book series is to highlight the best-implemented worldwide policies, projects, and research dealing with renewable energy and the environment. The books are developed and published in partnership with the World Renewable Energy Network (WREN). WREN is one of the most influential organizations in supporting and enhancing the utilization and implementation of renewable energy sources that are both environmentally safe and economically sustainable. Contributors to books in this series come from a worldwide network of agencies, laboratories, institutions, companies, and individuals, all working together towards an international diffusion of renewable energy technologies and applications. With contributions from most countries in the world, books in this series promote the communication and technical education of scientists, engineers, technicians, and managers in this field and address the energy needs of both developing and developed countries.

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Ali Sayigh • Antonella Trombadore •
Gisella Calcagno
Editors

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Brighton, UK

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Introduction

“Getting to Zero: Beyond energy transition towards carbon-neutral Mediterranean cities” was the guiding theme of the seventh edition of the Med Green Forum, held at the Department of Architecture of the University of Florence from February 14 to 16, 2024.

Since the first edition in 2010, the World Renewable Energy Congress and Network has organized the bi-annual Med Green Forum to emphasize the strategic role of renewable energy applications in Mediterranean buildings and cities. In recent years, marked by an escalation of energy crises and an acceleration of climate change, the regeneration of the built environment is even more recognized as a pivotal action not only to reduce energy consumptions and negative environmental impacts, but also as the best pathway to improve urban resilience and quality of life.

As a mission, the Med Green Forum focuses on the distinctive and unique socio-climatic and cultural milieu of the Mediterranean basin, where an effective implementation of Renewable Energy and Energy Efficiency Solutions (REES) should act as a beacon of light for the rest of the world. Here, the transition of the built environment towards lower environmental impacts has to account for the extraordinary biodiversity of landscapes and cultural value of historical urban settlements, considering the wide presence of heritage and protected buildings. As much as challenges, these peculiarities represent a huge opportunity to rethink and improve practices, tools and approaches for sustainable urban transformations, making the Mediterranean a living laboratory for innovation.

Within this evolving context, the Med Green Forum serves as an open and inclusive roundtable for an international community of researchers, experts and enthusiasts to share and debate the most promising strategies and technologies able to address the green objectives.

Envisioning ambitious future scenarios, aligned with the European Green Deal, the objective of MGF7 was to discuss the complexities of the ongoing energy transition and to explore the new possibilities coming from innovative carbon-neutral solutions, in order to lay the foundation of new processes and policies for sustainable Mediterranean cities. Here, a new balance should be found between the valorization of tangible and intangible heritages, shaping the strong cultural identity of

places, and the need to elaborate decarbonized scenarios. Since this revolutionary process requires time, the call for change is urgent: finding solutions to rethink human habitats from a carbon-neutral perspective to effectively reach net zero emissions by 2050.

As a transversal challenge, “Getting to zero” encompasses the transformation of territories, cities and buildings, deeply intertwined with evolving social dynamics in emerging energy landscapes. Acknowledging the multi-scalarity nature of these issues, the Med Green Forum collected contributions according to the following four main sessions, framing the discourse across the levels of cities, buildings, technologies and people.

Session 1. Landscape and Cities in Transition

Characterized by an inestimable historical and cultural value, Mediterranean rural and urban landscapes require a careful transition, addressing the global imperative of contrasting climate change while accounting for the needs of preservation and valorization.

The objective of zero emissions at the scale of territories can be reached by putting into play the most effective green principles in the planning of rural/urban infrastructures, public spaces as well as in the provision of innovative services. Particular attention is given to the role of nature-based solutions in urban areas and to the integration of renewable energy sources. In parallel, smart cities concepts require consideration of the growing amount, variety and quality of available digital data, enabling us to tackle complexity through more reliable processes and more inclusive ways of working.

Topics included:

1. Changing energy landscapes
2. Urban resilience and climate change
3. Positive energy districts/Energy communities
4. Energy system integration/Scenarios for renewables
5. Digital Twin, IoT, AI for energy efficiency
6. NBSs and biodiversity
7. Predictive planning and design
8. Citizen involvement/participation

Session 2. Architectures for Tomorrow

The regeneration challenge in Mediterranean cities lies in the renovation of the consolidated park of existing buildings (from public to private), extremely “energi-vorous” and sometimes characterized by poor environmental quality. While Mediterranean architectures for tomorrow will not be new constructions, the run towards renovation will not start from scratch: the millennia-old building traditions of exploitation of the natural resources of sun, air, water and soil/vegetation is increasingly regarded as the key to drive a sustainable renovation. As “construction materials”, natural elements can contribute to reaching positive energy targets through the integration of the most traditional and innovative technologies for the Mediterranean climatic and socio-cultural context, from natural and passive strategies to active renewable energy systems. The strategic adoption of these principles in the renovation wave can be sustained by the advancements in digital technologies, both in the design phase and along the building life-cycle, to support a more efficient use, management and operation, also involving the users of the future sustainable, healthy, and beautiful, green buildings.

Topics include:

1. Positive energy buildings/Green architecture
2. Nature-based solutions for energy efficiency
3. Innovative retrofits, renovations and deep renovations/Energy renovation of the cultural heritage
4. Bioclimatic and passive strategies for NZEB
5. Application of digital tools for innovative design process
6. Innovative co-planning and co-design approaches

Session 3. Eco-technologies and Materials

To renovate the Mediterranean built environment, the design of more sustainable buildings and living spaces requires a well balanced integration of traditional/innovative technologies and materials, appropriate for the unique climatic, cultural and socio-economic context of the Med basin.

Challenging standardized and mass-produced building systems, technological green innovations are joining climate-neutrality goals with sustainable socio-economic models (e.g. circular economy) towards cleaner and more sustainable building processes, supported by the most promising digital possibilities of Industry 4.0 and beyond, such as IoT and AI.

Topics include:

1. Renewable energy technologies/Green technologies
2. Eco and recycled materials/Life cycle design towards low carbon footprint
3. Active materials/BIPV
4. Digitized production of building elements

5. Digital technologies for efficient building management/Sensors, IoTs & AI/
Adaptive process and enabling technologies

Session 4. People and Communities

“Getting to zero” can be realistically reached and sustained only by a collective effort based on a shared awareness of how cities and buildings work and of what their real impact is on the environment, such as on the economy and on the society. The global run towards decarbonization requires people, from experts to ordinary citizens passing through the young generations, with an improved understanding and management of the living spaces, as a basis for a conscious and proactive behaviour. More virtuous human processes can be addressed by an even more strategic deployment of the newest digital technologies for the building sector, from sensors to IoT systems to responsive Digital Twins.

Topics include:

1. Human environmental comfort and wellbeing
2. People engagement for energy awareness and proactive behaviours
3. Living Lab experiences
4. ICT platforms for user experience of building management
5. Sustainable/energy communities
6. Energy for post anthropocentric society
7. Educational and training
8. Policies and finance

More than 100 researchers and experts from 22 countries attended the MGF7 and actively participated to the debate: these proceedings represent the main scientific output, comprising 85 full papers organised in the 4 identified sessions.

Ali Sayigh
Antonella Trombadore
Gisella Calcagno

Contents

Time in Environmental Design: How to Survive on Artificial Wings. . . .	1
Maria Luisa Germanà	
Part I Landscape and Cities in Transition	
What Needs to Be Demonstrated: The Potential Benefits of an NbS (Nature-Based Solutions) Project in a Postdisaster Reconstruction Context, the Case of the Reconstruction of the Al Haouz Region in Morocco	17
Nawal Benabdallah	
Energy Transition and Environmental Sustainability in Large Commercial Systems: A Research Project Example	29
Simone Forastiere, Cristina Piselli, Carla Balocco, Andrea Silei, and Fabio Scieurpi	
A Solarpunk Vision of the City and Its Infrastructure	41
Paolo Carli	
Innovative Approaches for Cultural Heritage Renovation in the Mediterranean Area	55
Valentina Frighi and Emanuele Piaia	
Exploring the Intersection of History and Morphology: A Comparative Study of the Spatial Formation in the Early Development of the Medina of Fez	69
Moujoud Lamiae and Messous Ouafa	
A Physics-Based Urban Digital Twin for Designing and Renovating Sustainable Cities	87
Benoit Beckers	
Analysing the Resilience of Microgrids as They Transition from Standalone to Grid-Connected Systems	97
Mohd Khairi B. Mohd Zambri and Eduardo A. Martínez Ceseña	

Integrating Transitions in Climate-Adaptive Design: A Nature-Based Approach Towards Next Resilient Amphibious Urban Environments Along Med Coasts	109
Ina Macaione, Alessandro Raffa, and Bianca Andaloro	
Towards Sustainable and Regenerative Cities: Vertical Farming as a Solution for Achieving Zero-Carbon Cities and Climate Neutrality: A Case Study of a Mediterranean City.	127
Sara Samir and Mohsen Aboulnaga	
Ecological and Bioregional Transition for Manhattan	143
Luca Buoniconti, Dora Francese, and Enrico Maria Oliva	
Living Labs to Design the Transition Towards Carbon Neutrality of Mediterranean Islands.	155
Riccardo Maria Pulselli, Gabriele Paolinelli, and Simone Bastianoni	
Designing Nature-Based Solutions for Climate Neutrality of School Communities	165
Stefano Magaudda, Serena Muccitelli, Carolina Pozzi, Federica Di Pietrantonio, Elena Neri, Gaia Esposito, and Riccardo Maria Pulselli	
Tailored Solutions for the Sustainable Transition of the Built Environment: The Specific Context as Information Source	177
Elisa Zatta and Massimiliano Condotta	
Seaweed House 2.0. Methods and Techniques to Harmonise and Improve the Living and Urban of Future Cities, Imitating Nature	191
Lucrezia Gelichi	
Sustainable Drainage Systems in City Centre: Open Problems and Technological Solutions	197
Elena Giacomello, Valeria Tatano, and Rosaria Revellini	
Mapping Urban Local Metabolism to Support Building Integrated Agriculture	207
Elena Lucchi, Matteo Clementi, and Valentina Dessì	
PV Cool: A Hybrid Solution for Power and Cooling Generation.	219
Rafael Monge Palma, Cristian Romero García, Paulo García-Melgar, Francisco Ruda Sarria, MPaz Montero-Gutiérrez, and MCarmen Guerrero Delgado	
Recovering Street Life Through Urban Climate Control Strategies: A Design and Assessment Tool.	231
Cristian Romero García, Rafael Monge Palma, MPaz Montero Gutierrez, Paulo García-Melgar, Teresa Palomo Amores, and José Luis Molina Félix	

Ventilation Results and CFD Model Formulation for Street Canyons Applied to Climate Control Strategies 241
 Francisco Ruda Sarria, Rafael Monge Palma, Teresa Palomo Amores, Paulo García-Melgar, MPaz Montero-Gutiérrez, and MCarmen Guerrero Delgado

Integrated Methodology for Thermal Comfort Assessment in Urban Environments: Validation in the City of Seville, Spain 253
 Teresa Palomo Amores, María de la Paz Montero Gutierrez, Rafael Monge Palma, Cristian Romero García, Francisco Ruda Sarria, and Servando Álvarez Domínguez

Microclimate Analysis of Urban Comfort Outdoors by Studying Anthropogenic Heat in Urban Canyons 263
 M^aPaz Montero Gutiérrez, Teresa Rocío Palomo Amores, Francisco Ruda Sarria, Paulo García Melgar, José Sánchez Ramos, and M^aCarmen Guerrero Delgado

Wind Farms and Diachronic Landscapes: The Identity of Sustainability 275
 Francesco Gugliotta and Alessio Battistella

Energy and Environmental Refurbishment of the Residential Complex of Torvecchia in Rome: Retrofitting and Demand Response Activities 285
 Mariangela Zagaria and Francesco Mancini

Shifting to a New Sustainable Paradigm: Nature-Based Solutions and Circular Design for the Urban Regeneration 297
 Roberto Bologna, Giulio Hasanaj, and Chiara Moretti

An Advanced Framework for Regenerative Design in Digital and Physical Prototyping. Crafting a Comprehensive Atlas for Predictive Modeling and Adaptive Technologies in Climate Change Scenario Analysis 313
 Domenico Lucanto

Adaptive Technologies in Flooding Scenarios Through NBS/SUDS. The Experimentation of an Innovative Protocol for the Resilience and Biodiversity Protection on the Coast of Reggio Calabria 325
 Giuseppe Mangano, Daniela Laganà, and Asmae Hanida

New Forms of Interaction Between Infrastructure and the City: The Experience of the Intensive Forest in the Garbatella Park in Rome 339
 Elena Paudice

A Novel Collaborative Stakeholder Development Tool Using Energy System Optimisation and Visual Interface for Workshop Facilitation 351
Owen Smith

Cities and Decarbonisation: An Assessment Model for the Technological Reconfiguration of Proximity Open Spaces..... 365
Paola Marrone, Ilaria Montella, and Federico Fiume

Smart Biophilic Cities: Green and Innovative Digital Solutions for Sustainable Urban Development 377
Lucia Montoni and Chiara Moretti

“Getting to Zero” the University Buildings Stock: Boosting the Renovation Strategy and the Action Plan of the University of Florence ... 391
Giacomo Pierucci, Antonella Trombadore, Gisella Calcagno, Lucia Montoni, Matteo Bertelli, and Carla Balocco

The Technological Design of Renewable Energy Communities: Architectural Implication of an Holistic Approach 401
Antonio Basti and Elena Di Giuseppe

Climate Neutrality and Global Perspective for Net Zero Policies and Buildings 419
Mohsen Aboualnaga and Maryam Elsharkawy

Constructing and Cultivating ‘The Urban Nature’..... 437
Rosa Maria Vitrano

Comparative Analysis of the Energetic Performance of Buildings Integrated Semi-Transparent PV Glazing Systems in the Climate of Hungary and Syria Title..... 449
Issam Khele and Márta Szabó

Part II Architectures for Tomorrow

Mediterranean Under Pressure: Architecture Resistance to the Climate Emergency 465
Martina Scozzari

Madonie Green Walls Revolution Sustainable Revitalization and Enhancement of Sicilian Inner Rural Areas..... 473
Luisa Lombardo, Simona Colajanni, and Tiziana Campisi

Explaining Positive Building Definition: A Review and Revision..... 485
Zinat Javanmard and Consuelo Nava

Energy Retrofit of Non-monumental, Historic Buildings: Limitations and Opportunities of Technological Advances..... 499
Alessandro Rogora and Paola Leardini

A Multicriteria Evaluation Tool for the Adaptive Regeneration of the Residential Heritage 513
 Cristiana Cellucci

Technological and Environmental Strategies for the Redevelopment of Outdoor Learning Spaces and the Establishment of Energy Hubs in School Buildings 525
 Andrea Canducci, Angela Calvano, and Alessandra Battisti

Bioclimatic Urban Renewal Approach on an Historical Disused Military Area in Naples 539
 Angelo Picariello, Dora Francese, and Paola De Joanna

CIS Roma Scuole Verdi: A Programme to Improve Energy Efficiency and Decarbonization by Retrofitting School Buildings 549
 Carola Clemente, Anna Mangiatordi, and Mariangela Zagaria

Adaptive Approaches to Attain Net Zero Through Carbon Sequestration in Heritage Sites of Coastal Mediterranean Cities 563
 Shahd Dergham, Abdelrahman Torkey, Menna Bassam, and Mohsen Aboulnaga

Investigating the Effect of Geometry to Approach Positive Buildings ... 577
 Zinat Javanmard, Consuelo Nava, and Adolfo Santini

Architectural Treatments for the Integration of Solar Energy Systems on the Roofs of Residential Buildings as an Alternative Solution to the Energy Crisis in Syria 591
 Samaher Wannous, Leen Wannous, and Rana Badr

Comfort at Work: Analysis, Evaluation and Design Proposal for an Industrial Building in Northern Italy 603
 Alessandro Rogora and Marc Roca-Musach

Architectural Regeneration Between Innovative Technologies and Cultural Heritage: Adaptive Reuse of School Buildings 615
 Alessandra Battisti and Adriano Ruggiero

Assessing Climate Change Adaptation of Buildings: A Review of Performance Indicators in Green Building Rating Systems 629
 Giancarlo Paganin, Cinzia Talamo, and Cristian Chitanu

Open-Source Tools to Support Local Circular Co-design 641
 Matteo Clementi and Marco Migliore

Nature Positive Buildings: Systemic Approaches and Technological Design Experimentation 649
 Antonella Violano and Monica Cannaviello

Holistic Redevelopment of a Coastal Heritage Area in Palermo (IT) ... 665
 Edoardo Cicala

Mediterranean Synergies for the Energy Renovation of University Buildings: Three Pilot Projects in Palestine, Tunisia, and Italy	681
Antonella Trombadore, Gisella Calcagno, Souha Ferchichi, Ines Khalifa, Chiheb Bouden, and Imad Ibrik	
The Digitalization of Participatory Approaches.	693
Antonio Cristino	
Green Architecture, NZEB, and Climate Neutrality. An Intervention Design Model for Deep Renovation of Public Housing	701
Fabrizio Tucci, Valeria Cecafozzo, Marco Giampaolotti, Gaia Turchetti, Kristina Mitrik, and Lavinia Montagner	
Environment, Technology, Architecture. Application of Green Technologies for the Rehabilitation and Energy Renovation of the Modern Built Heritage.	713
Andrea Dechamps and Maria Pilar Vettori	
Adopting Circular Economy Strategies in Building Regeneration Through a Holistic Approach.	727
Letizia Dipasquale, Fabrizio Battisti, and Melania Perdonò	
Part III Eco-Technologies and Materials	
European Drive to Use Photovoltaic Application in New Buildings in 2025	741
Ali Sayigh	
Material Synergies and Industrial Symbiosis to Valorize Granite Scraps from Quarries in Sardinia.	749
Antonello Monsù Scolaro and Fausto Barbolini	
Bio-Based Materials for the Improvement of “Zero Km” Human Quality Life	759
Marco Bellomo, Tiziana Campisi, and Simona Colajanni	
Bio-Based Materials to Foster Efficient Retrofitting of the Existing Building Stock	771
Chiara Scanagatta, Martina Bortolotti, and Massimiliano Condotta	
Reusing Olive Pomace Waste for Energy-Saving Applications in Construction: Development of a Panel Prototype.	787
Manfredi Saeli, Adriana Calà, and Federica Zagarella	
Mapping Local Resources in the South-East of France Bioregion: Climate as Project Material.	799
Gianluca Cadoni, Chiara Silvestri, and Christel Marchiaro	
Experimental Development and Proof of Concept for Natural-Based Cool Pavements	815
Paulo García-Melgar, Rafael Monge Palma, Paz Montero-Gutiérrez, Cristian Romero García, Francisco Ruda Sarria, and Servando Álvarez Domínguez	

Green Responsive System (GRS): A Paradigm Shift in Urban Decarbonization in the Mediterranean Context 827
 Eliana Catalano and Consuelo Nava

A Zero-Waste Strategy Toward Carbon Neutrality: Circular Technology Experimentations for Life Extension of Nonrecyclable Plastic Packaging 841
 Francesca Giglio and Francesco Armocida

Eco-Design for Transition Architecture: Comparative Analysis for an A-Scalar Methodology Using PNACC-Defined Green Actions and Predesign According to Life Cycle Thinking 853
 Domenico Lucanto and Federico Filice

An Integrated Approach Towards Smart Building Strategies to Mitigate Climate Change and Attain the SDGs in Architectural Education and Knowledge to Reach Net Zero 865
 Mohsen Abounaga, Ahmed Abouaiana, Asmaa Eid, Salma Aboughoneima, Aya Elmarakby, and Rana Elkeshki

When Architectural Design Unveils the Ethical and Aesthetic Value of BIPV: The Santa Verdiana Demo Case 889
 Gisella Calcagno, Antonella Trombadore, Giacomo Pierucci, and Lucia Montoni

Circular Building Production in the South Mediterranean Area: The Experience of CUBÂTI Project 903
 Maria Luisa Germanà and Fakher Kharrat

From Waste to Resource Using Recycled Stone in 3D-Printed Building Elements 913
 Katia Gasparini

Low Carbon Bio-Based Building Materials from Organic Waste: A Closed-Loop Production Model Within Circular Neighbourhoods ... 927
 Fabrizio Tucci, Serena Baiani, Paola Altamura, Violetta Tulelli, and Gabriele Rossini

Part IV People and Communities

Empowering Circular Economy Transition in the Building Sector: A Stakeholder-Centric Approach in the Design Phase for Climate Change Mitigation 941
 Fuat Emre Kaya and Antonello Monsù Scolaro

ESG Measurement Tool: An Approach to Measure the Sustainability Introduced in Real Estate Requalification Projects 953
 Alice Paola Pomè and Gianandrea Ciaramella

Building Climate-Resilient Cities: A Systemic and Participatory Design Process 969
 Debora Giorgi and Claudia Morea

Building BIM Competence: Learning in the DIGITAL DECATHLON 981
 Grunwald Gregor, Alves Sharina, Bertelli Matteo, Calcagno Gisella, Czmocho Ireneusz, Dudzinska Emilia, Heins Christian, Hollermann Sebastian, Kelm Agnes, Kokkonen Juuso, Laakkonen Ossi, Matveinen Mikko, Meins-Becker Anica, Piotr Bartkiewicz, Trombadore Antonella, and Zeisberg Loreen

Environmental Comfort and Well-Being: Unlocking Complexities of Human Behaviour Towards Climate Change Mitigation—Assessment of an Apartment in a Selected Hot Urban Area in the Mediterranean Region 999
 Mai M. Barakat and Mohsen M. Aboulnaga

Housing Adaptability for Aging in Place. Sustainable Approaches to Improve Environmental Comfort 1015
 Tiziana Ferrante, Federica Romagnoli, and Teresa Villani

The Moroccan Medina: Between Preservation and Sustainability in Light of the HUL Recommendation 1031
 Pr. Imane Bennani, Youssef Hentour, and Yasmine Belbaita

Modelling Sustainable Climate Shelters: Analysis of Energy Dynamics and Comfort Index at a Public Transport Stop 1043
 M^aPaz Montero Gutiérrez, Cristian Romero García, Teresa Rocío Palomo Amores, José Sánchez Ramos, José Luis Molina Félix, and M^aCarmen Guerrero Delgado

Proposal of a Framework to Evaluate the Building Performance of Local Healthcare Facilities 1055
 Laura Sacchetti

Which Living Lab Processes for the Renewable Energy Communities? A Pilot Experimentation in NRRP-T4Y Research 1071
 Giuseppe Mangano

MED_MESS Diversity, Creative Entropy, and Mediterranean Informality Practices 1085
 Maria Vittoria Arnetoli, Eleonora Giannini, and Margherita Vacca

Agile Approach to Sustainable-Decarbonized Strategic Transition Mediterranean Facility Management Industries: Novel Case Study in Egypt 1117
 Ahmed Abouaiana and Ahmed Khamis

Index 1139

Circular Building Production in the South Mediterranean Area: The Experience of CUBÂTI Project



Maria Luisa Germanà and Fakher Kharrat

1 Circular Production: A Solution Not Yet Achieved to the Limits of Natural Resources

In the age of the Anthropocene, the production of artefacts has a greater quantitative impact than in any previous epoch, to the extent that global human-made mass, outcomes of technological processes, have now surpassed all the living biomass [5]. This impact is a consequence of the linear production model, which took over after the First Industrial Revolution and was consolidated until the whole of the twentieth century: according to this model, at one end of the production there is the subtraction of irreproducible resources from nature (raw materials, energy sources), at the other end there is the addition of materials considered useless and undesirable (waste). The impact of linear production has also been qualitative, to the extent that the word ‘waste’, in its double meaning of wastage and rubbish, can comprehensively identify contemporary society [9]. The awareness that the linear production model is unsustainable is now widespread and incontrovertible. This awareness arose in the early 1970s, based on the realisation that natural resources are finite: essays fundamental to the advent of the very concept of sustainability were

Conference Session

Eco-technologies and materials

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published in the same years [3, 10], when the first photograph of the Earth, the famous ‘Blue Marble’ (taken on 07/12/1972 by the Apollo 17 space mission), clearly showed even to the uninitiated the finite nature and fragile balance of the planet inhabited by human beings.

However, it cannot be ignored that the dominant production model globally is still the linear one: the erosion of natural resources used as raw materials and as energy sources remains highly unsustainable: ‘Today, the world is 7.2% circular, a percentage that is getting worse year on year, driven by rising material extraction and use (...). This means more than 90% of materials are either wasted, lost, or remain unavailable for reuse for years as they are locked into long-lasting buildings and machinery. Each year, we have smashed through the planet’s safe environmental limits’ [2], as the shortening in the calendar of Earth Overshoot Day shows: in fact, it changed as a global figure from late December to early August in just over fifty years (<https://www.footprintnetwork.org/our-work/earth-overshoot-day/>). Therefore, the question of how to disseminate the principle of circularity in operational reality still remains pressing, in order to reverse this nefarious trend.

This is why, first of all, it is useful to understand the reasons for the ineffectiveness of scientific reports and appeals that have been insisting on the emergency of resource constraints for over 50 years, going unheeded because of the ‘Cassandra Effect’. The incomplete and insufficient adherence to circularity can be considered, as with climate change, a ‘wicked problem’, which would require such radical changes in the very structure of society as to be politically unsolvable and become a taboo, to be tackled by settling for small steps: ‘But, if we cannot implement wide sweeping, global actions, we can at least do our best to mitigate the negative effects of the problems that the LTG (*Limits to Growth*) study had already identified in 1972: resource depletion, persistent pollution, and soil erosion; all symptoms of the ‘overshoot’ conditions in which the human society finds itself. Considering that the perfect is the enemy of the good, we may consider a policy of small steps which are still better than nothing and have the advantage of being feasible. ‘Small steps’ in this context means pushing for measures which are flexible and which can be progressively adapted to changes in the extent of the problems and in the public understanding of the situation [1, p. 103].

Looking at the case of the built environment and its related interventions, the spread of circular production is even more urgent today than it was underlined with the European Green Deal, when construction as a resource-intensive sector was placed at the centre of strategies aiming at climate neutrality by 2050 [4]. Indeed, immediately after the COVID-19 pandemic, global trends saw an increase in the consumption of non-renewable energy resources and CO₂ emissions.

The use of raw materials in construction has further increased and contributes to the current environmental overload. This highlights the strategic aspect of research into energy efficiency in the production of building materials and secondary materials in construction: ‘In G7 countries alone, material efficiency strategies, including the use of recycled materials, could reduce greenhouse gas emissions in the material cycle of residential buildings by over 80 per cent in 2050’ [13, XXI].

Such a strategy, referring above all to the technical level, to be effective must be accompanied by strategies referring to the technological level, acting on the entire production process from planning to the management of interventions. This emphasises the role of the design phase, in which the prefigured solutions can be incisive in many ways: (1) extending the useful life of buildings and their components; (2) minimising construction and demolition waste; (3) reducing energy requirements related to comfort with passive solutions for lighting, heating, cooling, and ventilation without installations; and (4) maximising the integration of renewable energy sources throughout the built environment.

Some characteristics of the building sector, such as the high complexity of production, the multiplicity of stakeholders, the difficulty of control, and the inertia to innovation, make the concrete adherence to the principle of circularity particularly problematic. The many attempts that have come to a halt on a technical level hardly succeed in affecting the majority of production processes, remaining confined to a naïve operational niche, despite the best intentions and research conducted in recent decades. This happens because experiments aimed at the technical verification of performance and operability of locally available construction materials often fail to find the appropriate links with technological-productive chains, remaining alien to economic and cultural contexts.

This opens the field to research that tends to address the ‘Circularity Gap’ in this sphere, bearing in mind that construction is the synthesis of technical, organisational, and cultural aspects and that, therefore, any advancement towards circularity must take into account the set of rules and behavioural codes that make each technological process feasible in the specific context. Such a consideration is consistent with the concept of *Baukultur* [culture of construction], centred on the principle that every intervention in the formation and transformation of the built environment is eminently a cultural fact, which in order to be of high quality must fit appropriately into the specific environmental and social identities of places [11].

2 The CUBÂTI Project in the Framework of the South Mediterranean Area

CUBÂTI (*Culture du bâti de qualité: Recherche, Innovation et Entreprise pour la Durabilité*) was a Strategic Project funded by the EU Cross-border Cooperation Programme Italie-Tunisie 2014–2020. The project took its name from the French translation of the German term *Baukultur*, which summarises the concept that the quality of the built environment is an outcome in which different factors are integrated [12]. A multi-dimensional and multi-scalar vision, in which material and immaterial aspects of the built environment are integrated, inspired the Project, which was in continuity with well-established research strands both at the Department of Architecture of the University of Palermo and at the École Nationale d’Architecture et d’Urbanisme in Tunis. In particular, the holistic vision of the built

environment, in which no clear distinction is made between the built heritage and the ordinary built environment, suggested a virtual bridge between the past and the contemporary, under the banner of sustainability.

Indeed, CUBÂTI's ambition was to strengthen the links between research, enterprise, and professionals in the field of sustainable construction, by leveraging some fundamental aspects of the common cross-border identity in which it is easy to grasp, at the same time, opportunities and vulnerabilities. In fact, on the one hand, on the Sicilian and Tunisian shores, the natural context finds many recurring elements, which since the past have nurtured parallel cultures, thanks to fruitful exchanges (of raw materials and products, people and knowledge), across the few miles of Mediterranean Sea that divide them. On the other hand, the consequences of climate change are looming over the same context, with desertification, fires, floods, and the migratory flows that precisely between Sicily and Tunisia show an unresolved intensification, whose price in terms of human lives has turned from emergency to ordinary.

The main activities of the Project were concentrated in three WPs: (1) Technology Transfer (joint experimentation of building materials linked to the common identity and models of construction elements (Fig. 1); design and construction of small buildings for demonstration purposes in Tunisia, with the use of materials linked to tradition). (2) Capitalisation and Mainstreaming (technical documents to facilitate the transfer of knowledge and technologies on sustainable building materials in Sicily and Tunisia; exchange of good practices at seminars, fairs, and through scientific publications; development of cooperation protocols on the culture of quality construction). (3) Mobility and development of common knowledge (support for



Fig. 1 Joint experiments on composite materials using agro-food waste: the planning phase of the joint protocol (Ph. CUBÂTI, 2023)

cross-border mobility for the development of human capital; creation of a web platform for sharing content; CUBÂTI Award for enterprise and professionals).

In different respects, all three of these WPs included activities of some interest for the theme of session 'Eco-technologies and materials' of MGF2024. On the technical level, joint experiments were developed to verify the main performance of building materials for finishing mortars to be used in parts of buildings not exposed to the weather. Building materials were selected that are linked to the common cross-border identity and consistent with both the objective of minimising the use of non-renewable natural resources and the principle of circular production. In fact, as binders, geo-materials were chosen that are widely available in the region and lend themselves to low resource-intensive production (gypsum and clay); as aggregates, waste from production activities that are usually unrelated to construction, but equally relevant in both regions (agriculture, livestock and aquaculture), was chosen: pistachio shells; orange pulp; palm leaves; mussel shells; prickly pear waste [7, 8].

The experiments were conducted on the basis of a common protocol, in order to obtain comparable results and provide the basis for research on other mix designs in future research [6]. Samples of the experiments were exhibited at trade fairs and then in permanent form at various locations of the project partners (Figs. 2, 3, and 4).

The construction of a pilot building at the headquarters of CITET (Centre International des Technologies de l'Environnement de Tunis) is connected to the WP Technology Transfer. This pilot building was built to contribute to the knowledge of the potential of the materials tested. For the structures, compressed earth blocks (CEB) were used, a material already produced and marketed in Tunisia, finished with plasters containing the mortars from the experiments conducted (Fig. 4).



Fig. 2 Exhibition of the specimens, Headquarters of CITET (Centre International des Technologies de l'Environnement de Tunis) (Ph. CUBÂTI 2023)



Fig. 3 Stand of the CUBÂTI Project at the ‘Salon de l’Ecoconstruction’ held in Tunis (3–5 May 2023), during the visit of Mme Sarra Zaafrani Zenzri, Ministre de l’Equipement et de l’Habitate, and of Mme Leyla Ben Jeddou, President of OAT (Ordre des Architectes de Tunisie) (Ph. CUBÂTI 2023)



Fig. 4 The pilot CUBÂTI building constructed at the CITET headquarters in Tunis (Ph. CITET 2023)

Among the activities of the other two WPs, some included the involvement of Sicilian and Tunisian entrepreneurs operating in the production of sustainable building materials, through the organisation of workshops for enterprises (Fig. 5), participation in seminars and trade fairs (Fig. 3), cross-border exchanges (Fig. 6), and the joint production of dissemination publications.



Fig. 5 Workshop on raw earth plasters, with the cooperation of Guglielmino S.r.l. Misterbianco (CT) (Ph. CUBÂTI, 2023)



Fig. 6 Workshop on reinforced concrete diagnostics, at CITET in Tunis, by TEMLAB (Palermo) (Ph. CUBÂTI, 2023)



Fig. 7 A moment of the CUBÂTI Youth Atelier, held at IEMEST in Palermo, where young participants were involved in the preparation of bio-based building materials, using agro-food waste and low-energy binders (Ph. CUBÂTI, 2023).



Fig. 8 Inauguration of the CUBÂTI Technoteca, at the Department of Architecture of the University of Palermo on 13th December 2023, in the presence of 50 children aged around 11 years old participating in the CUBÂTI Youth Atelier (Ph. CUBÂTI 2023)

It is expected that the echo of the CUBÂTI Project’s activities will extend over time, thanks to the involvement of young people (Fig. 7) and the creation of demonstration models placed in the project partner universities, in dedicated spaces, visited on educational and orientation occasions aimed at schools (Fig. 8). The focus on involvement with the younger generations is consistent with the intergenerational vision that underlies the very concept of sustainable development.

3 Conclusion

The CUBÂTI Project was a short but intense experience and certainly could not have provided exhaustive answers to the Circularity Gap problem in the construction field. In spite of all its limitations, worsened by general administrative and managerial circumstances that have placed quite a few obstacles in the way of project realisations, the CUBÂTI experience has paved the way for future developments in cooperation, above all by indicating the need not to circumscribe circular production to mere technical flows of construction materials, but to focus on the management of these flows, which involve people and organisations.

Circular production, in the field of construction as for any artefact, should be based on the renewal of the cultural paradigm underlying every technological process, integrating tangible and intangible aspects and overlapping as much as possible the spheres of the users and the experts.

The presence of a rich and stratified built heritage, which in the southern Mediterranean represents a strongly connoting element of local identity with multiple cross-border commonalities, certainly constitutes a potential driver towards sustainability through circular production.

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Maria Luisa Germanà was the Scientific Responsible and Coordinator of the Project; Fakher Kharrat was Scientific Responsible of the Partner École Nationale d'Architecture et d'Urbanisme Tunisia.

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