

Research Group

Energy Efficiency & Environment - E3

Reference year:

2025

Scientific Coordinator:

SIBILIO Sergio / Full Professor / Department of Architecture and Industrial Design / Università degli Studi della Campania "Luigi Vanvitelli"

Group members:

MAFFEI Luigi / Full Professor / Department of Architecture and Industrial Design / Università degli studi della Campania "Luigi Vanvitelli"
ROSATO Antonio / Full Professor / Department of Architecture and Industrial Design / Università degli studi della Campania "Luigi Vanvitelli"
SPASIANO Mario / Full Professor / Department of Architecture and Industrial Design / Università degli studi della Campania "Luigi Vanvitelli"
IANNACE Gino / Associate Professor / Department of Architecture and Industrial Design / Università degli studi della Campania "Luigi Vanvitelli"
MASULLO Massimiliano / Associate Professor / Department of Architecture and Industrial Design / Università degli studi della Campania "Luigi Vanvitelli"
CIAMPI Giovanni / Associate Professor / Department of Architecture and Industrial Design / Università degli studi della Campania "Luigi Vanvitelli"
SCORPIO Michelangelo / Assistant Professor / Department of Architecture and Industrial Design / Università degli studi della Campania "Luigi Vanvitelli"
SPANODIMITRIOU Yorgos / Ricercatore / Department of Architecture and Industrial Design / Università degli studi della Campania "Luigi Vanvitelli"
TOMA Roxana Adina / Research Fellow / Department of Architecture and Industrial Design / Università degli studi della Campania "Luigi Vanvitelli"
EL YOUSSEF Mohammad / Research Fellow / Department of Architecture and Industrial Design / Università degli studi della Campania "Luigi Vanvitelli"
TEIMOOZADEH Ainoor / PhD Student / Department of Architecture and Industrial Design / Università degli studi della Campania "Luigi Vanvitelli"
MOKHTARI Niluofar / PhD Student / Department of Architecture and Industrial Design / Università degli studi della Campania "Luigi Vanvitelli"
SABET Parinaz / PhD Student / Department of Architecture and Industrial Design / Università degli studi della Campania "Luigi Vanvitelli"
ISTIANI Noor Fajrina Farah / PhD Student / Department of Architecture and Industrial Design / Università degli studi della Campania "Luigi Vanvitelli"
TUFANO Luigi / PhD Student / Department of Architecture and Industrial Design / Università degli studi della Campania "Luigi Vanvitelli"
LUSTRISSIMI Emiliano / PhD Student / Department of Architecture and Industrial Design /

Università degli studi della Campania "Luigi Vanvitelli"
PERROTTA Achille / PhD Student / Department of Architecture and Industrial Design /
Università degli studi della Campania "Luigi Vanvitelli"
GARRET FATELA Joao / PhD Student / Department of Architecture and Industrial Design /
Università degli studi della Campania "Luigi Vanvitelli"
CIOFFI Federico / PhD Student / Department of Architecture and Industrial Design / Università
degli studi della Campania "Luigi Vanvitelli"
MERCURI Rita / PhD Student / Department of Architecture and Industrial Design / Università
degli studi della Campania "Luigi Vanvitelli"
CERMOLA Daria / PhD Student / Department of Architecture and Industrial Design / Università
degli studi della Campania "Luigi Vanvitelli"
FERRARA Corrado Vittorio / PhD Student / Department of Architecture and Industrial Design /
Università degli studi della Campania "Luigi Vanvitelli"
GRAVINA Nicola / PhD Student / Department of Architecture and Industrial Design / Università
degli studi della Campania "Luigi Vanvitelli"
JAMIL Maryam / PhD Student / Dipartimento di Architettura e Disegno Industriale / Università
degli studi della Campania "Luigi Vanvitelli"
REA Giusi / PhD Student / Department of Architecture and Industrial Design / Università degli
studi della Campania "Luigi Vanvitelli"
LODICO Dana / PhD Student / Department of Architecture and Industrial Design / Università
degli studi della Campania "Luigi Vanvitelli"
ABRUZZESE Luigi / PhD Student / Department of Architecture and Industrial Design / Università
degli studi della Campania "Luigi Vanvitelli"
ANDREOZZI Benito / PhD Student / Dipartimento di Architettura e Disegno Industriale /
Università degli studi della Campania "Luigi Vanvitelli"
BILOTTA Massimo / PhD Student / Department of Architecture and Industrial Design / Università
degli studi della Campania "Luigi Vanvitelli"
EJAZ Khawaja Talha / PhD Student / Department of Architecture and Industrial Design /
Università degli studi della Campania "Luigi Vanvitelli"
OZDEMIR Revsen / PhD Student / Department of Architecture and Industrial Design / Università
degli studi della Campania "Luigi Vanvitelli"
SANTORO Fabio / PhD Student / Department of Architecture and Industrial Design / Università
degli studi della Campania "Luigi Vanvitelli"

Description of research lines:

- *SMART FAÇADES* - The research line on the Smart Façades is focused on the analysis and characterization of the building envelope performances, as well as on the development of adaptive and interactive dynamic (SMART) façades. In particular, the research aim is to analyze and characterize all building envelope components that help in reaching the built environment thermo-hygrometric, visual and acoustic comfort and reducing the energy consumption, while developing methodologies and simulation models for the innovative dynamic and bioclimatic components, such as the ventilated façade printed by 3D technology. The research line also investigates the "intelligent" façades and their components, studying how they can take advantages of sources and dynamic natural energy, their adaptiveness to the external stimuli, as well as how it is possible to transmit interactive messages into urban scenarios.

- *SOLAR DISTRICT HEATING AND COOLING* - This research line focuses on the analysis of district

heating and cooling systems, serving small/micro-scale typical Italian districts, based on the exploitation of solar energy and integrated with a seasonal borehole thermal energy storage as well as short-term thermal energy storage. The research activities are performed from a simulation point of view by means of the dynamic simulation software TRNSYS (carried out at Ri.A.S. laboratory) upon varying the boundary conditions (size and technology of components, control logics, thermo-physical properties, back-up systems, climatic conditions, layout of components, etc.), as well as experimental measurements on short-term thermal energy storage (carried out at SENS i-Lab laboratory).

- *INTEGRATED SOLUTIONS FOR DAYLIGHT AND ELECTRIC LIGHTING* - This research line concerns the analysis of solutions for the integration of artificial lighting with natural light through shielding systems and LED sources, in order to ensure visual comfort conditions through a Human Centric Lighting (HCL) approach. Through the preparation of a living-lab, a low-cost commercial intelligent system will be studied, integrating two motorized shading devices and six dimmableLED fixtures with different selection of related color temperatures (CCT).
- *LOW CARBON, HIGH COMFORT INTEGRATED LIGHTING* – The research line scope is on general lighting systems for indoor environments and the impact of buildings' facades on their urban environment. The focus is laid on lighting appliances in non-domestic buildings. Technically the research line deals with integrating: (i) daylight utilization by enhanced facade technologies and other architectural solutions, (ii) electric lighting schemes addressing technology and design strategies in the context of progressing digitalization, as well as (iii) lighting control systems and strategies related to visual and non-visual user needs with special emphasis on the interface of day- and electric lighting. All the above-mentioned aspects will be considered under the constraint of low carbon emission in a circular economy context.
- *FAULT DETECTION AND DIAGNOSIS* - This research line is focused on the analysis of different types of faults at several severity levels in typical Heating, Ventilation and Air-Conditioning (HVAC) systems including an air-handling units. In particular, the research mainly aims at both assessing the impacts of such faults on indoor thermo-hygrometric conditions, energy demands, CO₂ emissions, and operating costs, as well as developing and applying a methodology for the fault detection and diagnosis. The research activities are carried out by means of field tests performed with and without faults on a typical existing HVAC system including air-handling unit, fully instrumented and allowing for the artificial implementation of different types of faults of varying severity (at SENS i-Lab laboratory), as well as via a numerical approach (at the Ri.A.S. laboratory), through the development and validation of simulation models based on the use of Artificial Intelligence techniques and dynamic simulation software (TRNSYS).
- *THERMOPHYSICAL PROPERTIES OF MATERIALS* - The research activity focuses on the experimental assessment of thermophysical properties (thermal conductivity, specific heat, and thermal diffusivity) of innovative materials for the building sector and heating, ventilation, and air-conditioning systems at the Ri.A.S. laboratory.
- *MICRO-WIND TURBINES* - The research activity aims to analyze the performance of micro-wind turbines (electric power generated less than 7 kW) upon varying boundary conditions such as wind speed, electric demand profiles, etc. The activities are carried out with a simulation-based approach using the dynamic simulation software TRNSYS at the Ri.A.S. laboratory, as well as by means of experimental tests in the wind tunnel of the Norwegian University of Science and

Technology (NTNU) laboratories.

- **GENESIS** - The multidisciplinary research line aims to develop innovative procedures and techniques for characterizing the state of conservation of degraded external surfaces of historical buildings on a territorial scale through non-destructive monitoring techniques. The research activities also aim to define an information technology platform for the management/conservation/enhancement of the cultural, artistic, and landscape heritage under investigation. **IMMERSIVE VIRTUAL REALITY FOR LIGHTING DESIGN** - immersive virtual reality can play an important role in lighting design, thanks to its ability to allow for a quick assessment between different design choices based on spaces, colours, and light. However, immersive virtual reality (iVR) has to guarantee immersive virtual environments with high perceived visual quality of the scene and simulate light distribution in a photometrically correct manner, in order to be effectively used for lighting design. The research activities aim to understand how iVR can be used for lighting design.

- **URBANSENSE: CITIZENS AS SENSORS** - The UrbanSense project is designed to enhance urban inclusivity through multifunctional wearable devices that collect environmental and physiological data. These devices monitor parameters such as air quality, thermal comfort, and acoustics, providing valuable insights for urban planning and citizen engagement. Citizens play an active role as “sensors,” wearing the devices and offering feedback to support real-time urban monitoring and planning. The project targets five municipalities in the Campania region, selected for their diverse socio-economic characteristics. A centralized platform will analyze the collected data using big data techniques to guide policy decisions and intervention strategies. UrbanSense integrates urban planning, technology, and social sciences to address environmental and social challenges. The project involves phases of research, wearable system development, field testing, and dissemination of results. Its ultimate goal is to promote inclusivity and sustainability while actively encouraging citizen participation in urban environmental monitoring.

- **WINDOW VIEW QUALITY IN BUILDINGS** – The research line focuses on the window view quality, through the transparent elements, of visual connection between the building and the urban environment, in order to evaluate a primary element of visual connection with the outside and its influence on the pleasant experience of the environment, well-being, comfort, and stress recovery, as well as real estate value. Window view quality is a subjective and objective parameter, namely, depends on the observer and, therefore, on contextual factors. These factors can be: (i) geometric (number of windows viewed, size of windows viewed, distance of windows viewed, etc.), (ii) temporal (timing of viewing, duration of viewing, etc.), and (iii) psychological (mood, occupant satisfaction, emotions, etc.). The research is carried out using simulation software, and subjective experimental tests in real and virtual reality environments.

- **HYDROGEN FUEL CELLS** - The research aims at the energy, economic and environmental analysis of innovative solutions for satisfying the electric demands of medium-large end-users (ports, airports, emergency camps, etc.) through modular systems based on the use of fuel cells fuelled with hydrogen. The work is performed with a numerical approach using dynamic simulation software (TRNSYS).

Relationships with other research groups of the University of Campania L. Vanvitelli during the last three years:

The “Smart Façades”, “Fault Detection and Diagnosis”, “Micro wind turbines”, “Hydrogen fuel cells” and “Immersive virtual reality as a tool for lighting design” researchlines have been carried out in collaboration with the Research Group of prof. Maffei from DADI.

The “GENESIS” researchline has been carried out in collaboration with the Research Groups of prof. Zerlenga, prof. De Matteis, prof. Faella and prof. Jacazzi from DADI.

Participation in research projects during the last three years:

Project title: Solar smart Energy Networks integrated with borehole thermal Energy storagesserving small-scale districts in the Campania region (S.E.N.E.CA.)

Scientific Coordinator: ROSATO Antonio

Call title: V:ALERE program (VAnviteLli pEr la RicErca)

Abstract: the project’s research activity is part of the "Solar District Heating and Cooling" research line. In particular, it concerns the study of district heating/cooling systems with seasonal thermal energy storage for 10 small districts with domestic/school users located in the Campania region, by means of a dynamic simulation software. The analysis of the proposed system is carried out from energy, environmental and economic points of view upon varying the boundary conditions, such as the climatic conditions, the energy requirements, the technologies, the components’ capacity, operating schemes and control patterns. The simulation results of the proposed systems are compared with those associated with conventional heating/cooling systems serving the same districts, in order to assess the potential benefits.

Involved persons: ROSATO Antonio, IANNACE Gino, CALABRÒ Marco, CIERVO Antonio, TOMA Roxana Adina, PELLEGRINO Rossana, PIETROSANTI Anton Giulio, DAOUD Hussein Sa'id Hussein.

Status: Funded

Project submission/start/end date: 13-02-2019 / 01-12-2019 / 02-12-2022

Project title: Integrated PRocedure for assEssing and improVing the resiliENce of existing masonrybell Towers at territorial scale (PREVENT)

Scientific Coordinator: DE MATTEIS Gianfranco

Call title: V:ALERE program (VAnviteLli pEr la RicErca)

Abstract: the project aim is to develop innovative procedures and techniques to characterize the conservation status of the degraded outdoor surfaces of bell towers on a territorial scale, using non-destructive monitoring techniques.

Involved persons: DE MATTEIS Gianfranco, ZERLENGA Ornella, SIBILIO Sergio, CENNAMO Claudia, ZIZI Mattia, BENCIVENGA Pasquale, CIAMPI Giovanni, CIRILLO Vincenzo, CICALA Margherita, IADEROSA Rosina, SPANODIMITRIOU Yorgos.

Others involved persons: SPURIA Letteria / Researcher / Ministry of Cultural Heritage and Activities, LATTE BOVIO Giuseppe / Researcher / SUNTA S.r.l., FALANGA Bruna / Researcher / PROTOM GROUP S.p.a., PERNA Mirko / Researcher / VIRTO360 Partners: Ministry of Cultural Heritage and Activities, SUNTA S.r.l., PROTOM GROUP S.p.a., VIRTO360

Status: Funded

Project submission/start/end date: 13-02-2019 / 01-12-2019 / 02-12-2022

Project title: UrbanSense - Cittadini come sensori: promuovere l'inclusione attraverso lo sviluppo e l'applicazione di un sistema indossabile multifunzionale per una città citizen- oriented

Principal Investigator: SIBILIO Sergio

Call title: Avviso pubblico per la selezione di proposte progettuali presentate da Università pubbliche ed Enti pubblici di Ricerca localizzati nelle regioni del Mezzogiorno per la realizzazione di attività di ricerca, sviluppo e sperimentazione negli ambiti di interesse dell'ecosistema RAISE - SPOKE 1 "Urban Technologies for Inclusive Engagement Ambienti e servizi urbani accessibili ed inclusivi"

Abstract: The UrbanSense project aims to transform cities into inclusive and citizen-oriented spaces by utilizing wearable sensors to collect environmental, social, and economic data. Through an interdisciplinary approach that integrates urban planning, technology, and social sciences, the project actively involves residents in data collection and analysis to develop innovative strategies to enhance urban sustainability, accessibility, and quality of life. The wearable devices, designed to be comfortable and reliable, will be calibrated and validated to ensure accuracy, while citizen feedback will guide interventions and policy decisions for more resilient and aware communities.

Personale coinvolto: SIBILIO Sergio, MAFFEI Luigi, ROSATO Antonio, MASULLO Massimiliano, CIAMPI Giovanni, SCORPIO Michelangelo, SPANODIMITRIOU Yorgos, GALDERISI Adriana, CASTANÒ Francesca, LIBERTI Roberto.

Status: Funded

Project submission/start/end date: 23-02-2024 / 31-05-2024 / 31-08-2025

Project title: Sviluppo di Sistemi Energetici Resilienti e Intelligenti per Comunità Energetiche Rinnovabili Residenziali e Commerciali (SERIREC)

Principal Investigator: NARDINI Sergio

Call title: Bando pubblico per la selezione di Proposte Progettuali per attività di ricerca di cui al programma di ricerca del partenariato esteso "Network 4 Energy Sustainable Transition – NEST", Codice Progetto MUR: PE00000021, Spoke 7 "Smart Sector Integration", CUP: E63C22002160007 a valere sulle risorse del Piano Nazionale Ripresa e Resilienza (PNRR), Missione 4 "Istruzione e ricerca", Componente 2 "Dalla ricerca all'impresa", Investimento 1.3, finanziato dall'Unione Europea - NextGenerationEU

Abstract: The project aims to develop dynamic simulation models and digital twins for integrated, resilient and intelligent energy systems for Renewable Energy Communities (REC) mainly composed of residential and commercial buildings. These systems, based mainly on renewable sources such as solar and wind, will be integrated with innovative energy storage systems, as well as modules for double-skin facades. Activities include modelling of electrical and thermal loads, development of control strategies for electronic power converters and thermal optimisation of thermal photovoltaic systems using innovative materials, and the calibration and validation of digital twins for the simulation and optimisation of Resilient and Intelligent Energy Systems for CERs. The multi-sector and multi-scale approach aims to improve efficiency, reduce primary energy consumption, emissions and operating costs while ensuring users' thermal, visual and acoustic well-being. *DADI Involved persons:* MAFFEI Luigi, SIBILIO Sergio, ROSATO Antonio, IANNACE Gino, MASULLO Massimiliano, CIAMPI Giovanni, SCORPIO Michelangelo

Vanvitelli involved persons: DE SANTIS Michele, LANGELLA Roberto, MORRONE Biagio, RUBINO Luigi, BUONOMO Bernardo, CASCETTA Furio, MAURO Alessandro, NARDINI Sergio

Status: Funded

Project submission/start/end date: 20-08-2024 / 02-01-2025 / 01-11-2025

Project title: UTMOST FDD: an aUToMated, Open, Scalable and Transparent Fault Detection and Diagnosis process for air-handling units based on a hybrid expert and artificial intelligence approach. From experimental open-data to transfer model learning for the enhancement of energy

management and indoor environmental quality in buildings. *Principal Investigator:* CAPOZZOLI Alfonso / Associate Professor / Politecnico di Torino *Co-Principal Investigator:* ROSATO Antonio
Call title: PROGETTI DI RICERCA DI RILEVANTE INTERESSE NAZIONALE – Bando 2022

Abstract: HVAC systems equipped with air-handling units (AHUs) are frequently operated in faulty conditions due to lack of proper maintenance, failure of components or incorrect installation. Faulty operation in AHUs leads to uncomfortable indoor environment, poor indoor air quality and serious energy wastes. To this purpose a Fault Detection and Diagnosis (FDD) process makes it possible to automatically recognize fault occurrence and identify the causes and the location of that fault contributing to enhance both energy efficiency and indoor environmental quality during building operation. In this context, this project proposes the development of an automated, open, scalable and transparent FDD process for AHUs based on a hybrid expert and artificial intelligence-based approach. The initial goal is the construction of an open reference dataset based on experimental campaigns characterized by high resolution measurements of both normal and faulty operation under different operation modes to be conducted on an existing monitored AHU system. The experimental dataset will represent a valuable source of knowledge for assessing the real impact of a number of typical faults in terms of cost, energy consumption and indoor comfort/air quality. Moreover, the data set will be exploited to calibrate a digital twin capable to mimic the observed operation of a typical AHU in both faulty and normal conditions and will make it possible to conduct robust fault impact scenarios and to enrich the experimental dataset extending the operating ranges of training data. A novel hybrid FDD strategies including both data-driven and knowledge-based models will be then developed based on the obtained experimental and simulation datasets. The hybrid FDD framework will make it possible to exploit the potentialities of physics-based models for description and interpretation of faults occurrence and of artificial intelligence to extract non-trivial knowledge from experimental and simulated data. Both the experimental data-set produced in the project together with the digital twin will be made publicly available on data repository well recognized by researchers opening the opportunity for the scientific community to perform replicability and benchmark studies on FDD processes for AHUs. The final objective is then testing the transferability and scalability of the conceived FDD strategy exploiting ontology schema and applying a transfer learning framework considering as a target system an AHU different from the one used for the development of the FDD strategy itself. The project will represent a cutting-edge experience considering the proposed holistic approach to the resolution of the main challenging issues in the field of FDD for AHUs. The flow of activities can be replicated also for other systems with the aim of supporting an easier penetration of advanced automatic FDD tools in the automation industry as a key and low-cost solution to enhance energy management in buildings.

Involved persons: ROSATO Antonio, MASULLO Massimiliano, SCORPIO Michelangelo, EL YOUSSEF Mohammad, MERCURI Rita.

Others involved persons: CAPOZZOLI Alfonso / Associate Professor / Politecnico di Torino, TRONVIL Paolo Maria / Associate Professor / Politecnico di Torino, CHIOSA Roberto / PhD Student / Politecnico di Torino

Partners: Politecnico di Torino

Status: Funded

Project submission/start/end date: 31-03-2022 / 28-09-2023 / 30-09-2025

Project title: GESTIONE del rischio SISmico per la valorizzazione turistica dei centri storici del Mezzogiorno (GENESIS)

Principal Investigator: DE MATTEIS Gianfranco

Call title: Avviso per la presentazione di progetti di ricerca industriale e sviluppo sperimentale nelle

12 aree di specializzazione individuate dal PNR 2015-2020

Abstract: The main objective of the research project is the development of an information technology platform for the management and mitigation of seismic risk aimed at the conservation and enhancement of the historical-monumental heritage. The project is organized into six Realization Objectives (RO) and involves the selection of nine case studies in Italian territory.

DADI Involved persons: Ornella Zerlenga, Giuseppe Faella, Sergio Sibilio, Danila Jacazzi, Giorgio Frunzio, Riccardo Serraglio, Marina D'Aprile, Giovanni Ciampi, Mariateresa Guadagnuolo, Corrado Chisari, Vincenzo Cirillo, Mattia Zizi

Partners: University of Reggio Calabria, Telenia S.r.l., Rielco Impianti S.r.l., Municipality of Caserta, University of L'Aquila, University of Pisa, University G. D'Annunzio of Chieti- Pescara, University of Basilicata, IUAV University of Venice, University of Bergamo, TAB Consulting S.r.l., Asdea S.r.l., Zugari Guido and C. S.r.l., Target Euro S.r.l., Kibernetes S.r.l., Fip-industriale S.p.A., Pro.ge.77 S.r.l., Sisia S.r.l., Boviar S.r.l., Consortium C.i.p.a.e., BASF CC Italia spa, EtnaHitechS.C.p.A., FIBRE NET S.r.l., Council for Public Works, ANCE – National Association of Building Contractors, Matera-Basilicata 2019 Foundation, Municipality of Matera, Municipality of Cosenza, Municipality of Potenza, Municipality of Fiumefreddo Bruzio, Municipality of Tricarico, Municipality of Piazza Armerina, Abruzzo Region, Basilicata Region, Tuscany Region, Diocese of Piazza Armerina, Pittini Group

Status: Funded

Submission/Project Start/End Dates: 22-12-2022 / 01-01-2023 / 01-07-2025

Project title: Design and Assessment of Innovative Textile and 3D-Printed Systems for Human-Centered Spaces (DANTEHUM)

Principal Investigator: Giovanni Ciampi

Call title: Bando per il finanziamento di progetti di ricerca fondamentale ed applicata dedicato ai giovani Ricercatori – Università degli Studi della Campania “Luigi Vanvitelli” *Abstract:* The project aims to evaluate the performance of innovative systems based on flexible materials (textiles and 3D printing) for solar irradiation control and the improvement of building envelope performance in terms of thermal and visual aspects, as well as enhancing occupant comfort. The project consists of three main phases: 1) definition of the state of the art, 2) experimental characterization, and 3) simulation and analysis of the designed façade systems. Throughout the entire project, research activities will be conducted at the Ri.A.S. Lab and SENS i-Lab laboratories.

Involved persons: Giovanni Ciampi, Sergio Sibilio, Michelangelo Scorpio, Martina Gargiulo, Davide Carleo, Parinaz Sabet, Niloufar Mokhtari, Ainoor Teimoorzadeh.

Status: Funded

Submission/Project Start/End Dates: 07-07-2022 / 01-09-2023 / 30-04-2024

Project title: New movable systems for smart/co-working taking advantage of life quality, sustainability and energy efficiency (RESTANZA)

Principal Investigator: CIERVO Antonio

Call title: Bando per il finanziamento di progetti di ricerca fondamentale ed applicata dedicato ai giovani Ricercatori – Università degli Studi della Campania “Luigi Vanvitelli” *Abstract:* The aim of the research project is to design a Prefabricated Movable Building (PMB) for smart/co-working a renewable energy-based, self-sustaining in energy use, eco- friendly, modular, and flexible in set-up, and its performance will be analyzed while operating in a selected suitable small village of the Campania region (Italy). The PMB will be developed to optimize occupants' well-being, energy performance, and integration of the indoor environment with outdoor architectural/historical/landscape elements via innovative design methods (immersive virtual reality

and dynamic simulation models). The project aims at 1) promoting the exploitation of renewable energy and energy-efficient systems via innovative design methods, 2) reducing the environmental/ecological footprint associated with both building and transport sectors, 3) suggesting an alternative lifestyle combining tradition and modernity, 4) facilitating social/economic rebirth of small villages with significant regenerative potential. The project provides relevant environmental/social/territorial/economic impacts, together with significant results for engineers, architects, manufacturers of PMBs, the scientific community, and policymakers.

Involved persons: CIERVO Antonio, ROSATO Antonio, CASTANÒ Francesca, MASULLO Massimiliano, MORELLI Maria Dolores, MARZOCCHI Raffaella, BOUCHERIT Samiha.
Status: Funded

Submission/Project Start/End Dates: 07-07-2022 / 01-09-2023 / 30-04-2024

Project title: Physically based and multi-objective approach for Cultural heritage valorisation through Virtual reality (PERCEIVE)

Principal Investigator: SCORPIO Michelangelo

Call title: Avviso pubblico di selezione per il finanziamento di progetti di ricerca fondamentale ed applicata dedicato ai docenti e ai ricercatori non destinatari di altri finanziamenti” della Università degli Studi della Campania Luigi Vanvitelli

Abstract: The PERCEIVE project aims to enhance the appreciation, accessibility, and preservation of cultural heritage through a novel approach utilizing IVR. It seeks to create detailed physically based digital twins that can be experienced in multisensory ways or used for lighting and acoustic design. This approach involves developing methodologies to accurately model complex architecture in IVR, ensuring high visual quality, realistic interaction with light and sound, and accessibility to hard-to-reach areas. The project will explore IVR applications in lighting design, preservation, drawing, and storytelling. Key objectives include reviewing existing IVR practices, establishing benchmarks for hardware and software, devising modelling techniques for complex architectures, creating digital twins of heritage buildings, and assessing user preferences.

DADI involved persons: SCORPIO Michelangelo, ROSATO Antonio, MASULLO Massimiliano, CIAMPI Giovanni, JACAZZI Danila, SERRAGLIO Riccardo, CIRILLO Vincenzo, CERMOLA Daria, REA Giusi, IADEROSA Rosina

Vanvitelli involved persons: IACHINI Santa

Status: Funded

Submission/Project Start/End Dates: 19-03-2024 / 01-09-2024 / 28-02-2025

Project title: WRENCH - Whispers of Time: Heritage as Narratives of Climate-Change *Principal*

Investigator: Prof. Marco Armiero (Autonomous University of Barcelona) *Call:* Collaborative Research Action (CRA) - Climate & Cultural Heritage (CCH) 2023

Abstract: WRENCH aims to address the effects of climate change on tangible and intangible heritage, while broadening the understanding of heritage to include narratives, narratives, and ephemeral legacies. WRENCH envisions cultural heritage as both something at risk and something that can tell a story about the risk we are all taking. WRENCH has the dual objective of (a) developing a transdisciplinary methodology involving environmental sciences, engineering and humanities to investigate the impact of climate change on tangible and intangible heritage; (b) use heritage as a storytelling tool to improve awareness of climate change.

Involves persons: CHISARI Corrado, DE MATTEIS Gianfranco, SCORPIO Michelangelo, SIBILIO Sergio

Partners: Autonomous University of Barcelona (proponente), Durham University, Orta Dogu Teknik Universitesi, Hidromod, Durham Castle, Diocesi di Ragusa - Chiesa Madre Duomo di San

Giorgio, Consorzio “Coop4Art”

Status: Funded

Submission/Project Start/End Dates: 08-09-2023 / 30-06-2024 / 30-06-2027

Scientific products during the last three years:

10 scientific publications in Class A journals and/or indexed in the Scopus/WoS databases:

- [1] Gargiulo, M., Carleo, D., Ciampi, G., Masullo, M., Chías Navarro, P., Maliqari, A., Scorpio, M. Assessment of the Historical Gardens and Buildings Lighting Interaction through Virtual Reality: The Case of Casita de Arriba de El Escorial. BUILDINGS, vol. 14, 2024, art. n. 273, DOI: 10.3390/buildings14010273
- [2] Sokol, N., Martyniuk-Peczek, J., Matusiak, B., Amorim, C.N.D., Waczynska, M., Kurek, J., Vasquez, N.G., Sibilio, S., Kanno, J.R., Scorpio, M., Nazari, M., Koga, Y., ‘Personas for lighting’. Three methods to develop personas for the indoor lighting environment, Energy and Buildings, vol. 278, 2023, art. n. 112580, DOI: 10.1016/j.enbuild.2022.112580
- [3] Rosato, A., Guarino, F., El Youssef, M., Capozzoli, A., Masullo, M., Maffei, L., Experimental assessment of ground-truth faults in a typical single-duct dual-fan air- handling unit under Mediterranean climatic conditions: Impact scenarios of sensors’ offset and fans’ failure, Energy and Buildings, vol. 275, 2022, art. n. 112492, DOI: 10.1016/j.enbuild.2022.112492
- [4] Spanodimitriou, Y., Ciampi, G., Tufano, L., Scorpio, M., Flexible and Lightweight Solutions for Energy Improvement in Construction: A Literature Review, Energies, vol. 16, 2023, art. n. 6637, DOI: 10.3390/en16186637
- [5] Ansari, M.A., Ciampi, G., Sibilio, S. Novel Materials for Semi-Transparent Organic Solar Cells, Energies, vol. 17(2), 2024, art. n. 333, DOI: 10.3390/en17020333
- [6] Salamone, F., Sibilio, S., Masullo, M., Assessment of the Performance of a Portable, Low- Cost and Open-Source Device for Luminance Mapping through a DIY Approach for Massive Application from a Human-Centred Perspective, Sensors, vol. 22(20), 2022, art. n. 7706, DOI: 10.3390/s22207706
- [7] Rosato, A., Guarino, F., El Youssef, M., Capozzoli, A., Masullo, M., Maffei, L., Faulty Operation of Coils’ and Humidifier Valves in a Typical Air-Handling Unit: Experimental Impact Assessment of Indoor Comfort and Patterns of Operating Parameters under Mediterranean Climatic Conditions, Energies, vol. 15(18), 2022, art. n. 6781, DOI: 10.3390/en15186781
- [8] Gentile, N., Lee, E.S., Osterhaus, W., Altomonte, S., Naves David Amorim, C., Ciampi, G., Garcia-Hansen, V., Maskarenj, M., Scorpio, M., Sibilio, S., Evaluation of integrated daylighting and electric lighting design projects: Lessons learned from international case studies, Energy and Buildings, vol. 268, 2022, art. n. 112191, DOI: 10.1016/j.enbuild.2022.112191
- [9] Scorpio, M., Laffi, R., Teimoorzadeh, A., Ciampi, G., Masullo, M., Sibilio, S., A calibration methodology for light sources aimed at using immersive virtual reality game engine as a tool for lighting design in buildings, Journal of Building Engineering, vol. 48, 2022, art. n. 103998, DOI: 10.1016/j.job.2022.103998
- [10] Spanodimitriou, Y., Ciampi, G., Scorpio, M., Mokhtari, N., Teimoorzadeh, A., Laffi, R., Sibilio, S., Passive Strategies for Building Retrofitting: Performances Analysis and Incentive Policies for the Iranian Scenario, Energies, vol. 15(5), 2022, art. n. 1628, DOI: 10.3390/en15051628

Additional 10 scientific products:

- [11] Scorpio, M., Ciampi, G., Gentile, N., Sibilio, S., Effectiveness of low-cost non- invasive solutions for daylight and electric lighting integration to improve energy efficiency in historical buildings, Energy and Buildings, vol. 270, 2022, art. n. 112281, DOI:

- 10.1016/j.enbuild.2022.112281
- [12] Vasquez, N.G., Amorim, C.N.D., Matusiak, B., Kanno, J., Sokol, N., Martyniuk- Peczek, J., Sibilio, S., Scorpio, M., Koga, Y., Lighting conditions in home office and occupant's perception: Exploring drivers of satisfaction, *Energy and Buildings*, vol. 261, 2022, art. n. 111977, DOI: 10.1016/j.enbuild.2022.111977
- [13] Salamone, F., Chinazzo, G., Miller, C., Sibilio, S., Masullo, M., Editorial: Innovative Human-Centric Investigations and Technologies for Human Wellbeing and Health in the Built Environment, *Frontiers in Built Environment*, vol. 8, 2022, art. n. 918643, DOI: 10.3389/fbuil.2022.918643
- [14] Rosato, A., El Youssef, M., Guarino, F., Ciervo, A., Sibilio, S., Experimental studies of air-handling units' faulty operation for the development of data-driven fault detection and diagnosis tools: A systematic review, *Energy Reports*, vol. 8, 2022, pp. 494-503, DOI: 10.1016/j.egy.2022.10.087
- [15] Salamone, F., Chinazzo, G., Danza, L., Miller, C., Sibilio, S., Masullo, M., Low- Cost Thermohygrometers to Assess Thermal Comfort in the Built Environment: A Laboratory Evaluation of Their Measurement Performance, *Buildings*, vol. 12(5), 2022, art. n. 579, DOI: 10.3390/buildings12050579
- [16] Amorim, C.N.D., Vasquez, N.G., Matusiak, B., Kanno, J., Sokol, N., Martyniuk- Peczek, J., Sibilio, S., Koga, Y., Ciampi, G., Waczynska, M., Lighting conditions in home office and occupant's perception: An international study, *Energy and Buildings*, vol. 261, 2022, art. n. 111957, DOI: 10.1016/j.enbuild.2022.111957
- [17] Rosato, A., Sibilio, S., Guarino, F., El Youssef, M., Entchev, E., Maffei, L., Field Performance of HVAC System Under Healthy and Faulty Conditions During the Summer: Preliminary Development of a Simulation Model Based on Artificial Neural Networks, *Smart Innovation, Systems and Technologies*, vol. 263, 2022, pp. 183-196, Proceedings of: 13th KES International Conference on Sustainability and Energy in Buildings, SEB 2021, 15-17 September 2021, Split (Croatia), DOI: 10.1007/978-981-16-6269-0_16
- [18] Ciampi, G., Spanodimitriou, Y., Scorpio, M., Rosato, A., Sibilio, S., Energy performance of PVC-Coated polyester fabric as novel material for the building envelope: Model validation and a refurbishment case study, *Journal of Building Engineering*, vol. 41, 2021, art. n. 102437, DOI: 10.1016/j.job.2021.102437
- [19] Rosato, A., Guarino, F., Youssef, M.E., Sibilio, S., Maffei, L., Preliminary symptoms assessment of typical faults related to the fans and humidifiers of HVAC systems based on experimental data collected during Italian summer and winter, *IOP Conference Series: Earth and Environmental Science*, vol. 897(1), 2021, art. n. 12009, Proceedings of: 4th International Conference on Renewable Energy and Environment Engineering, REEE 2021, 27-30 August 2021, Florence (Italy), DOI: 10.1088/1755-1315/897/1/012009
- [20] Rosato, A., Guarino, F., Sibilio, S., Entchev, E., Masullo, M., Maffei, L., Healthy and faulty experimental performance of a typical HVAC system under italian climatic conditions: Artificial neural network-based model and fault impact assessment, *Energies*, vol. 14(17), 2021, art. n. 5362, DOI: 10.3390/en14175362

Relationships with international and national Companies, Institutions, Research Centers, Universities during the last three years:

Research topic SMART FAÇADES:

Scientific collaboration with Dr. Lars Gullbrekken from the Department of Architecture, Materials and Structures, SINTEF Community, SINTEF AS (Trondheim, Norway). Industrial research collaboration with COSMIND s.r.l. with regard to the research: "Smart Façades" associated to the activities of the Industrial PhD in Technologies for Resilient Living

Environments

Research topic SOLAR DISTRICT HEATING AND COOLING:

Scientific collaboration with the research group of the “Tokyo University of Agriculture and Technology” (Tokyo, Giappone), led by prof. A. Akisawa.

Scientific collaboration with the research group, led by Prof. Evgueniy Entchev, of the research center Canmet Energy Research Centre - Natural Resources Canada (Ottawa, Canada).

Scientific collaboration with the research group, led by prof. Walaa Al-Smadi, of the Department of Mechanical Engineering - National University College of Technology (Amman, Jordan).

Scientific collaboration with il prof. Mohamed G. Ghorab, Department of Mechanical Engineering, Alexandria University, Alexandria, Egypt.

Research topic LOW CARBON, HIGH COMFORT INTEGRATED LIGHTING:

Scientific collaboration with Dr. Jan de Boer, Fraunhofer IBP (Germany) and Prof. Niko Gentile, Lund University (Sweden), with regard to the research: “Applications and case studies”

Scientific collaboration with Dr. Jan de Boer, Fraunhofer IBP (Germany), Dr. Barbara Szybinska Matusiak, NTNU (Norway) and Jan Wienold, EPFL (Switzerland) with regard to the research: “Visual and non-visual requirements”.

Scientific collaboration with Dr. Jan de Boer, Fraunhofer IBP (Germany) and David Geisler-Moroder, University of Innsbruck (Austria), with regard to the research: “Digitalized Lighting Solutions (Technology & Design Tools / Process)”.

Research topic FAULT DETECTION AND DIAGNOSIS:

Scientific collaboration between the Department of Architecture and Industrial Design and the research group, led by Prof. Evgueniy Entchev, of the center Canmet Energy Research Centre - Natural Resources Canada (Ottawa, Canada).

Scientific collaboration between the Department of Architecture and Industrial Design and the research group, led by Prof. Capozzoli Alfonso, of the Politecnico di Torino.

Research topic GENESIS:

Industrial research collaboration with TELENIA s.r.l. within the framework of the project "Seismic Risk Management for the Touristic Enhancement of Historical Centers in the Southern Italy (GENESIS)."

Research topic REALTA' VIRTUALE IMMERSIVA PER LA PROGETTAZIONE ILLUMINOTECNICA:

Scientific collaboration with Dr. Jan de Boer, Fraunhofer IBP (Germany), David Geisler-Moroder, University of Innsbruck (Austria), Justyna Martyniuk-Peczek and Natalia Sokol, Politechnika Gdańska (Polonia)

Research topic WINDOW VIEW QUALITY IN BUILDINGS:

Scientific collaboration with Dr. Jan de Boer, Fraunhofer IBP (Germany), Justyna Martyniuk-Peczek and Natalia Sokol, Politechnika Gdańska (Polonia)

Research topic MICRO WIND TURBINES:

Scientific collaboration with prof. Tania Bracchi from Norwegian University of Science and Technology (NTNU), Trondheim, Norway.

Research topic HYDROGEN FUEL CELLS:

Scientific collaboration with the company ASSING S.p.A., Monterotondo 00015, Italy.

Collaborations with Consortia, Scarl or other Institutions participated by the University of Campania Luigi Vanvitelli during the last three years:

-

ISI Web of Science Subject Categories:

Architecture
 Computer Science, Software Engineering
 Engineering, Environmental
 Engineering, Multidisciplinary
 Environmental Studies
 Ergonomics
 Optics
 Physics, Applied
 Public, Environmental & Occupational Health Thermodynamics

Scientific-Disciplinary Sectors:

IIND-07/A (ex ING-IND/10)
 IIND-07/B (ex ING-IND/11)
 IUS/10

Keywords:

Solar Energy
 District heating and cooling systems
 Seasonal thermal energy storage
 Short-term thermal energy storage
 TRNSYS
 HVAC systems
 Smart façades
 Heating, Ventilation and Air-Conditioning (HVAC) systems
 Air-handling units
 Fault diagnosis and detection

ERC Categories:

PE2_15 - Thermodynamics
 PE6_12 - Scientific computing, simulation and modelling tools
 PE6_9 - Human computer interaction and interface, visualization
 PE7_3 - Simulation engineering and modelling
 PE8_11 - Environmental engineering, e.g. sustainable design, waste and water treatment, recycling, regeneration or recovery of compounds, carbon capture & storage
 PE8_6 - Energy processes engineering
 PE8_3 - Civil engineering, architecture, offshore construction, lightweight construction,

geotechnics

SH7_5 - Sustainability sciences, environment and resources, ecosystem services PE6_7 - Artificial intelligence, intelligent systems, natural language processing PE8_10 - Manufacturing engineering and industrial design