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Centro de Investigação em Arquitetura, Urbanismo e Design

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Fundação para a Ciência e a Tecnologia
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Rethinking Architectural Design for Innovative Actions on Novel radiantT energies

The building as a Power Cell

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Keywords

Clean energy; Architectural engineering; Energy-oriented shaping; Transpowering radiant energy; Ecotectonics

Partner Institutions
IAAC - Institute for Advanced Architecture of Catalonia

NUACA – National University of Architecture and Construction of Armenia – Faculty of Architecture

Expected Future Partner Institutions
GIC-Lab, Genova – Italy

WUT - Warsaw University of Technology - Department of Architecture

FMHOUSE – Madrid

OBJECTIVES

This project aims to prepare the basis for wider research on the role of architecture in the context of a decarbonized society, where energy production and consumption will be integrated locally through buildings as clean energy production cells without the need for energy storage or grid dependency. For this purpose, we will organize an exhaustive survey of the current systems for the production and storage of clean energy, compatible with a ubiquitous and discreet integration in the architecture of buildings. Also exploring the potential of natural principles for biomimetic and bioinspired applications in new shapes and materials to integrate innovative strategies for the use of natural radiant energy present in the atmosphere in the context of a conceptual repositioning of architectural engineering and design.

Additionally, it is intended to integrate collaborating researchers from Master and Ph.D. programs; Prepare a Field Guide with the products derived from the survey and organize a preliminary colloquium under the subject - The building as a Power Cell - as a strategy for strengthening the research network and establishing partnerships with the industry.

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ABSTRACT + IMAGES

Over the ages of civilizational evolution, Architecture, as the art of shaping space, retained an intrinsic capacity of modeling societies and collective life.

The real correlations between design, engineering, and biology, about the functioning of the biological component of the living beings, introduces an operational capability, opening doors, to a quasi-divine understanding of man's actions on territory, allowing both parts to coexist in harmony. Moreover, the evolution of knowledge in these areas opens opportunities for new creative chimeras, in which architecture cannot be unheard.

Energy consumption growth stems from the growing need to support information systems that ubiquity circulates through space and things. Unfortunately, this ambition has led to an extreme phenomenon recognized as “climate change”, which forces us to develop adaptive processes and endure on an environment always stepping away from what we are "programmed" to live in.

In general, architecture, science, and art have always embodied the spirit of invention and the breakdown of established barriers. Today, more than ever, we are experiencing times of fusion and sharing of resources and strategies. The future of humankind depends on objective responses to inescapable phenomena of a scale never observed before. The challenge of creativity emerges once again as hope to overcome obstacles and unexplained prejudices.

Today we can predict the performance of engineered materials, engineered systems, structures, or buildings. However, there is an inherent disconnect when investigating Nature’s materials, with little understanding of how functionality arises from both the material and complex structure with properties and interactions across scales. New developments enable a new perspective through the convergence of many scientific disciplines, and advancements in technology empower us to understand systems from the “bottom-up”. If we hope to learn from Nature, we need a new holistic perspective for the research procedures.

By investigating nature properties, examining fundamental links between processes, structures, and properties at multiple scales and their interactions, it is possible to understand system functionality from the level of its building blocks. Furthermore, the transfer of natural material principles towards biomimetic and bioinspired applications in the architectural field, studying the interfaces between living and nonliving systems, holds a great potential, where material concepts from biology might enable the bottom-up development of new structural concepts, new materials and new architectural concepts.

The convergence of biology, mathematics, arts, engineering, and computational techniques have resulted in the toolset necessary to describe complex material systems, from nano to macro, and can unlock Nature’s secret to high-performance materials and shapes, contributing to developing a new understanding of architecture and to the potential of exploiting novel concepts in the design of buildings.

Today, we have hybrid materials with memory, with the capacity for self-regeneration, self-cooling, among many others that we observe in the structures that we recognize as natural. Moreover, these materials will progressively incorporate other mimetic capacities taken from nature and inevitably point us to the possibility of integrated energy production through the conversion of the energetic potential existing in the planet’s atmosphere. Thus, making possible one of the most significant paradigm shifts in recent history.

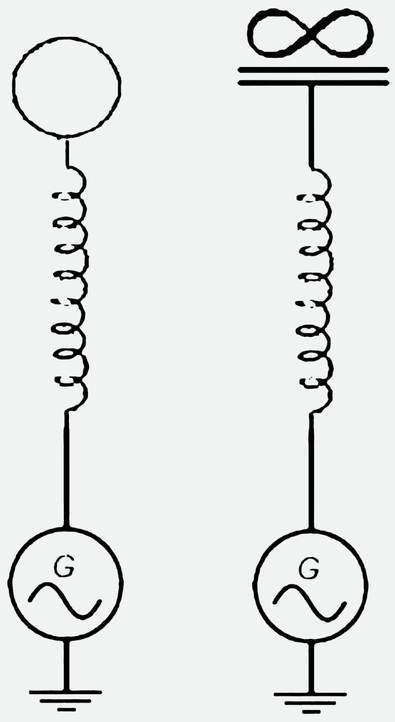
With this impetus, the present project will explore the potential aspects of clean energy generation, focusing on studying the mechanisms for integrating and managing energy on a multi-scaled materials approach, based on architecture as the main field of application.

This project encompasses identifying state of the art in this field, referring and classifying books, articles, and journal papers under this exciting field of research, making them also accessible to the broader community in general.

It should also provide a valuable reference for architects, engineers, materials scientists, and researchers in both academia and industry and hopefully ignite extended discourse and inquiry in architecture education.

Indeed, many technical details are still not wholly understood and controlled at this moment; for this occasion, we are presenting fundamental concepts and ideas to be settled during de development and maturing of the project. Many of the current references are adapted from previous studies carried out by the researchers, and some of the discussion should therefore not be considered yet as a comprehensive review concerning the broader range of available results. Instead, they represent specific illustrative examples, including theoretical aspects, associated principles, and applications.

The growing trend towards incorporating integrated management systems in the creation process, with powerful virtualization and simulation capabilities (BIM), allows looking at the phenomenon of construction and architectural establishment in an entirely new way. In the sense of the uncertainty generated by the possible inadequacy of humankind to an accelerating environmental change, the concerns about climate security are exacerbated by the exponential increase of the world population that occurred in the last decades. Furthermore, the instability arising from the scarcity of resources and its unproportioned territorial distribution contributes to the need to consider new values in architectural and urban thinking, to find exceptional solutions for buildings, cities, and communities, designed as attractive places for people and expressions of local culture, offering a beautiful and optimistic view of life…



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SCIENTIFIC RELEVANCE FOR THE DISCIPLINE

The bond between natural and artificial systems, between human and non-human mediators, is a critical part of a new engagement with form and material. If the discipline of architecture has gravitated toward the subject of tectonics, the consciousness that a building is a device for environmental regulation is shifting the focus of the discipline from tectonics to ecological and thermodynamic processes. Buildings establish the regime of energy exchange between built and natural environments by its geometry, materiality, and context. In this lies an opportunity to establish relationships between these performances and emerging architectural sensibilities. The project will explore these relationships and aim to relate energetic performance with material, tectonic, visual, and spatial nature through newly available instruments that allow new limits for architecture. From the goal of incorporating new energy technologies in the design and building technology, merging bioinspired thermodynamic processes in structures, we will mobilize a series of new tools to explore in the context of architectural sensibility that seeks to evolve it.

EXPECTED ECONOMIC AND SOCIAL IMPACT

We hope this project will interest industry researchers in related fields and professors who are teaching advanced courses in the architectural field. Although architecture is a very interdisciplinary field, it draws on knowledge from many disciplines, through studying the examples of today's innovative clean energy production processes, we expect that the outputs of the project will gain insights that help them to address other problems in the field of architecture evolution.

We also believe that this project will be relevant to new and soon-to-be university and college graduates who will next turn their focus on technology transfer from university to industry and prepare them to address today's environmental challenges.

During the development of new projects, unexpected results emerge that have the potential to make further improvements in a concept or enable completely new products. Thus, we believe that discoveries while introducing new materials and new approaches to architecture morphology may serve as critical pillars of innovation that drive economic, social, and cultural progress.

RESEARCH PLAN AND TASKS

All sciences are connected; they lend each other material aid as parts of one great whole, each doing its own work, not for itself alone, but for the other parts; as the eye guides the body and the foot sustains it and leads it from place to place. Out of man's mind in free play comes the creation Science. Roger Bacon, Opus Tertium (1266–1268)

The primary goal of this research is to provide an architectural operative overview in the field of clean energy, including earlier work and future opportunities and intellectual challenges for research, contributing to change the paradigm of architectural praxis, consolidating roots in technical and constructive aspects of architectonic shapes, facade design, and integrated energy production. In this embryonic approach, it is intended to implement a research strategy based on four exploratory phases to test and improve the project to prepare its competitive submission in R&D contests. In this sense, the planning of the tasks is not yet possible to detail completely. This fact results in a strategy that starts with the characterization of the art's state, followed by the fine-tuning of methods and tools. The next stage will engage with the experimentation, criticism, and confrontation of results in scientific meetings to be promoted. The project is designed to be implemented over 18 months. Each stage will last six months, with the possibility of overlapping some of the tasks, mainly those resulting from the preparation of dissemination actions, exploratory contacts with partner entities, and the preparation of the process for FCT financing or others.

Stage I: Evaluation on systems for the production and storage of clean energy. (6 months)

Building an Architectonic Perspective on the current systems for the production and storage of clean energy, compatible with a ubiquitous and discreet integration in the architecture of buildings, will provide the basis for a more comprehensive understanding of the role of buildings in the context of a decarbonized society. This fact is significant because the entire field is being developed and potential applications explored without considering a sense of harmonization integrated with the values of architecture. The outside resources and investigations we refer to are not intended to encompass architecture per se yet contribute to its (re)foundation and future progress. Admittedly, we are standing on the shoulders of others and declaring their work to be in a newfangled (and sometimes yet unproven) field. Therein lays the stimulus for such a paradigm: only by the convergence of disparate fields can architecture find its worth from the astute combination of advancements in chemistry, biology, physics, materials science, and engineering. In this stage, tasks associated with the critical inventory of solutions that already exist in the field of capture and storage of clean energy will be developed, prioritizing those most appropriate for a ubiquitous and discreet integration in the context of architecture.

For this purpose, the starting point comes from the seminal principles of Nicola Tesla, Vicktor Schauberger, that, among others, dedicated their lives to the observation of Nature and the understanding of its most sublime phenomena in the search for intelligent ways of harvesting and mastering the energies necessary for the life and actions of humanity, without thereby offending the necessary balance of Nature. As the main task, it is assumed the production of a Guide to Renewable Energy Technologies Applied on Architecture under the perspective of recognizing the principles of biomimetic and bioinspired shapes and materials to integrate innovative strategies for the use of natural radiant energy present in the atmosphere.

Stage II: Methods and Tools (6 months)

In this second step, we will refine the methods and tools to be used in the development of case studies, considering that the set of computer tools and laboratory recourses are in constant evolution and necessary for experimental research in architectural engineering and design. A selection of the most promising strategies for investigating architecture and analyzing the properties and behavior of complex materials will be reviewed, with examples, case studies, and theoretical basis where appropriate. Finally, the strategy of practical approach will be defined, for the elaboration of digital and physical prototypes that allow exploring new concepts and resources of architecture, from the potential of the ideas identified in 1st stage of the project. In this phase, the resources and knowledge offered by the research partners will be intensely involved, with particular emphasis on the laboratory resources offered by FAUL, NAUACA, and IAAC, where the intention is to establish the bases for carrying out physical and virtual prototypes testing.

Stage III: Applied Architectonic experimental solutions. (6 months)

The role of architecture will always be to shape original models for resource use to create a habitat beneficial to human happiness. Thus, it will be imperative to transpose this to the multiple scales and contexts of intervention, potentiating different approaches, considering the local cultures and the available material resources. Thus, the liberation of energy contingency would be enshrined, assuming the architecture itself as a self-sufficient energy cell, where energy capture and consumption components are ubiquitously integrated into the materials and construction systems, from the most straightforward house to the most complex industrial building.

Applied Architectonic experimental solutions illustrate how we can immediately benefit from this approach. Application of new principles and approaches has already been undertaken on a variety of systems throughout different fields of research, and we intend to develop fields that allow us to identify those where we can best contribute and innovate, being our priority to emphasize two significant lines of study: Morphogenesis and parametric form-finding strategy for energy-oriented modulation and optimization; Innovative solutions in façade design; Trasnpowering radiant energy solutions by layering new materials as a (r)evolution on traditional ones.

Based on an interdisciplinary exchange, in close collaboration between scientific fields, focused on the prototype's development in a laboratory-oriented environment, at this stage we will try to contribute for the intersection between the creative aspects and the conditions of production, to allow to test the limits of formal and technological innovation in an effective experimental environment.

The focus on the integration of state-of-the-art design tools, three-dimensional modeling, and functional prototyping to full-scale, focused on the integration of BIM tools and parametric models of interaction, will lay the foundation to meet the challenges of demanding international competitiveness, consolidating knowledge and encouraging the registration of patents, models, construction systems and even new materials.

Final remarks: As mentioned, in parallel with the exploratory approaches to be carried out in each of the identified stages, there will be a permanent critical follow-up to allow to improve all aspects of the project in order to ensure the solidity of a qualified process to compete at the highest level by institutional sponsoring.

Within the scope of this embryo project, a large share of the resources will be channeled to reinforce de network and celebrate cooperation protocols that guarantee the levels of commitments required for the good execution of the general objectives. Likewise, a strong effort will be made to achieve international visibility through the creation and maintenance of a website dedicated to the project, with a particular focus on creating a discussion platform centered on the concept - The building as a Power Cell - as a strategy for strengthening the research network and establishing partnerships with the industry.

EXPECTED SCIENTIFIC RESULTS

The current embryo project has as main scientific objectives to fulfill, within the time foreseen for the 18 months of its execution, the conclusion of three master's dissertations (incorporating students from de MIARQ) and at least the integration of two PhD students as researchers. Concerning the scientific outputs, the goal is the submission for publication at least three scientific articles (one per phase of the project) with peer review, indexed, as well as the production of an e-book in English, with an electronic version in open access to be made available on the project website. The partnership with the International Conference on Building Science, Technology and Sustainability will permit to integrate the theme of - The building as a Power Cell - at the ICBSTS2022 conference, which is scheduled to take place in Lisbon, with the publication in the proceedings, which are also indexed. Concerning the project's production, in the scope of phase 3, we believe that it is possible to register models and, eventually, even a patent if the embryo-project "germinate" and reach FCT / EU funding, a level where international partnerships already established may have a boost.

BUDGET: € 7.500,00

The budget structure of the embryo-project is based on the division of costs into four categories: Services and Materials; Equipment & Software; Missions and Dissemination, to be affected over the 18 months of the project's execution:

Services and materials: 1000€ - the amount will be used to cover expenses for Materials for experimental tests, Website support and Translation services; Equipment & Software: 4000€ - the amount will be used to cover expenses with the purchase of 2 Laptop Computers for general research support, a Thermal IR Camera for preliminary model tests and readings, a Digital multimeter for recording experiences and licensing of specialized Software; Missions and dissemination: 2500€ - the amount will be used to cover expenses with exploratory missions with partners and laboratories, and, whenever possible, online meetings are encouraged, as well as expenses with Fees for registration in events, congresses, and publication of papers in specialized magazines. The execution implies the initial investment in Equipment & Software, the remaining items being diluted over the 18 months of the embryo-project.