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Sinergii în mediul urban

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ABSTRACT

The habilitation thesis represents the synthesis of my research, academic and professional career after finishing my doctoral studies. This milestone from my professional path marked the beginning of a wonderful, challenging and rewarding adventure. The manuscript has two main directions: (1) professional, scientific and academic achievements and (2) the development plan.

The thesis begins with a short introduction which offers an overview of the work, given the initial research initiatives and the evolution **from occupant's need for comfort to the urban interactions in terms of pollution, energy, environment** etc. Even if the evolution of the subjects and problematics has been from individual to community, the main issues still require answers, thus the development plans are built on the same pillars.

My scientific achievements, built as joint results within CAMBI team, undertake several research fields: *thermal comfort, experimental and numerical applied fluid mechanics, air distribution strategies, indoor environmental quality (IEQ), building energy efficiency, green buildings, renewable energy systems and urban sustainability*.

In the above research fields, we have obtained promising results used further on by other researchers, architects and engineers and published the work in ISI journals, BDI journals and international conferences. Throughout the years, I have managed more than 9 research and consultancy projects and been involved more than 10 national and international research teams. The interest in the subject of comfortable, healthy, energy efficient buildings has guided me along the studies and scientific work. I am first degree Energy Auditor in buildings and systems, certified BREEAM assessor for green buildings, member of REHVA Technical and Research Committee, fact that reoriented me to **sustainable and comfortable building concept** understanding the constraints found in European policies on energy and environment. This technical knowledge is important for my career since it allows me to keep focused on applied science in **building design and policies**.

Thus, given my gained expertise through the research performed, I become **energy expert for European Commission Horizon 2020 Calls, energy efficiency expert for World Bank and independent expert for UNDP Moldova** on the new green code for buildings.

The starting point of the research career, the PhD thesis, had as objective finding new ways of getting the **optimal thermal comfort** of the occupants by reconsidering the theory of comfort. The main objectives of this study were to gain insight on the influence played by the local turbulence of the air on the thermal comfort of HVAC (Heating, Ventilation and Air Conditioning) users.

Connected with this research, CAMBI team started national and international collaborations, led by Prof. Ilinca Nastase, proposing three national Grants PN-II-ID-PCE-2011-3-0835-INADEVA, PN-II-PT-PCCA-2011-3.2-1212-EQUATOR and PN-II-PT-PCCA-2013-4-0569-INSIDE where I have been a team member of the and actively participated to the writing of the project proposals, opening the path to research project management.

The interest for new adventures and, more important, the confidence given by a great team (Ilinca Nastase, Florin Bode, Mihnea Sandu and other wonderful colleagues), were the main ingredients of a successful development.

The knowledge gained during the doctoral period had two main directions: **numerical simulation and experimental campaign focused on airflow research** which were further extended at building envelope level through the Post-Doctoral funding in the national project "*Innovative ventilated envelope elements for solar heat recovery in low energy buildings*" - PN-II-RU-PD-2012-3-0144.

Along with CAMBI team, we have been the pioneers of the **transpired solar collectors (TSC)** research domain in Romania. The publications resulted from previous research activities of CAMBI team proved that the optimization of the geometry perforation of TSC is very important, leading to almost 20% increase in energy efficiency compared to other cases from literature[1]. The purpose of the articles published by the team members[1-18] is to prove the efficiency increase of lobed geometries, underlining the benefit of passive solar systems. The team has tested different types of perforation geometry on the transpired solar collector. They have proved that a lobed geometry can significantly increase the heat transfer. The complex fluid dynamics generated by **certain types of lobed geometries can be directly linked to the temperature increase of airflow**. The study reveals the importance of certain characteristics of solar collectors which can improve with almost 15% the thermal efficiency. The streamwise vortices induced by the lobed shaped perforation help in the stabilization of the jet flows inside the ventilated cavity. The more complex dynamics of the lobed flows, it results a **better heat transfer rate** [2, 19].

CAMBI team has integrated **thermal energy storage materials within the solar collector and we used organic paraffin** as phase change material with high latent heat storage, suitable for building applications according to the literature and obtained a heat transfer efficiency higher with up to 38% and a higher number of operating hours compared to low inertia TSC (the energy stored within the PCMs being released during the night slowly) [20]. Many research articles, project proposals, 1 patent and different PhD thesis have been generated by this research domain. The intermittence of solar radiation has led to the integration of PCM elements in TSC, which has been the subject of another grant, *SCOPE* - PN-III-P2-2.1-PED-2016-1154 -*Intelligent solar collector with phase change materials integration*, in collaboration to Politehnica University team, **increasing the energy efficiency and the stability of the overall system** [6, 21]. The SCOPE project ended with a patent regarding the optimized TSC system (*patent 2018 00463: Opaque ventilated facade element with integrated phase changing materials for solar energy passive use*) and a dynamic simulation model for the stability regime.

The previous results were further integrated in the prototype house, built during the *project CIA-CLIM*, PN-III-P1-1.2-PCCDI-2017-0391, "*Smart buildings adaptable to the climate change effects*", where I am the UTCB team leader[12]. The project **demonstrated the possibilities of TSC integration at building level**. The project proposes the improvement of institutional collaboration between three universities and two research institutes for the revival of the research activities and transfer of knowledge between partners. The 4 component projects, centred on the **efficient energy buildings**, are focused on two principal research directions: (i) use of smart facades with low-thermal transfer, actively integrated for the enhancement of internal comfort and possessing a passive control of energy (by using the solar energy) and (ii) smart energy efficiency through building automatization and solar energy collectors. The resulted system, the smart house, is conceived thus to minimize the input energy for maintenance.

The previous results of the team were relevant to the concept of the project BISCUIT "*Building integrated solar crop dryer for food preservation in urban farming applications*"- PN-III-P2-2.1-PED-2019-4165, tackling different research areas: **drying process, solar drying, inertial elements**

behavior research, **PCM building envelope integration, transpired solar collectors** etc. The activity regarding study of TSC has a long tradition at UTCB-CAMBI Research Centre, starting with research direction for implementing the lobed geometry perforations. The main components of the BISCUIT demonstrator are the **TSC with lobed geometry perforations, the turbulent flow intensification elements inside the dryer and the cascaded PCM spheres on the heated air duct**, which will be linked to the fresh air system or to the drying chamber, depending on the needs. The **adaptive PCM sector** is part of the air duct, being composed of **3 cascaded temperature zones for phase change**. This **novel building integrated solar dryer can be hosted by urban farms located on multi-residential building rooftops** owned by the residents of the condominium or by urban farms located on industrial building such as supermarkets. For each application, the solar dryer is used for heating building spaces during cold period and for urban farm drying needs during warmer period. The solar dryer is an option of sustainable food waste management, it can be used for the conversion in dried products of surplus food or fruits and vegetables considered as not marketable by the supermarket.

On the aspect of **airflow inside buildings**, another research project was implemented, in **partnership with the main water provider in Bucharest: SC APA NOVA SA**. The project *"Environment improvement of Sludge dewatering from the wastewater treatment system by Optimizing the Local Effluent Capture and Treatment"* -SOLECT- PN-III-P2-2.1-BG-2016-0158 aimed defining an **optimal solution for ventilation** of the zone for high dehydration of the sludge to improve technological parameters and working conditions, after the partner's requirements. To solve malfunctioning ventilation system problems, Apa Nova SA decided collaboration with UTCB in order to provide an optimal ventilation solution, obtained using the latest technologies available in the University. The research team performed **concentration measurements, numerical studies conducting air flow (CFD) and experimental investigation by optical techniques (PIV and LDV)** and also proposing solutions supported by the best technical skills of the team. The project aimed defining an optimal solution for ventilation (**adapting the existing general ventilation system and preparation for the introduction of local ventilation solutions**) of the hall for highly dehydrated sludge and improvement of technological parameters and working conditions.

Starting with 2013, under **my coordination**, along with other colleagues, at UTCB there have been developed **2 master theses** of: Mihai Mira and Daniel Bordianu, **2 research Erasmus fellowships**: Baptiste Bazire et Paul Leclerc, IUT St Lo, **2 research AUF- "Eugen Ionescu" PhD and post-doc fellowship** for Abdelouhab Labihi, from Cadi Ayyad University Marrakech, and **1 Erasmus research traineeship** for Tournois Quentin - INSA Lyon, all regarding the thermo-dynamic evaluation and optimization of solar collectors. Thesis of **Dr. Andrei Bejan was entirely financed by SCOPE Project** and co-supervised over the entire PhD stage.

Being more and more interested in the sustainability part, another research field was developed at UTCB-CAMBI Research Centre, as mentioned in BISCUIT project: coupling the solar collectors with **drying systems for solar urban applications**. The solar drying systems have gained interest starting with the collaboration with **Dr. Abraham Tetang Fokone**, from Cameroun University, who was the beneficiary of a Eugene Ionescu Grant in our University under my coordination, on a subject related to optimization of drying process using the solar energy. On the other hand, the research projects in collaboration with Prof. Ashish Shukla, from Coventry University, have generated new research directions on transpired solar collectors and PCM elements thermal behaviour optimization. Moreover, the **ongoing PhD thesis of MSc. Charles Berville** is related to the study of energy efficiency of a solar drying system, to increase the solar energy use and reduce the food and energy

waste. The need for low energy food preservation solutions, along with the interesting results already obtained by the proposed team [5, 19, 20, 22, 23] lead to a new, innovant concept of a system for pre-heated building fresh air during the cold period and providing heated air for drying process of the crop resulted from local urban farming during the warm period.

In 2020, at the kind invitation of Dr. Horia Petran, researcher at INCĐ URBAN-INCERC and president of pRO-nZEB Cluster Association, I have become the representative of UTcb and **member of the Advisory Board in pRO-nZEB Cluster Association**, an important actor in the field of low energy buildings. This opportunity gave me the **perspective of energy policies at urban and regional level**, being able to actively involve and to collaborate with public administrations.

Starting from the current year, I **lead the Romanian teams for two Horizon 2020 projects**.

The project nZEB ready (H2020-LC-SC3-EE-2020-2) – *“Enhancing Market Readiness for nZEB Implementation”* aims to prepare ready to use **frameworks to answer the needs related to lack of awareness, lack of skilled professionals and lack of support instruments, implementing the nZEB ready labelled procedures** in *5 pilot countries* in order to obtain a broader range of results, representative at European level. Focused on unblocking the nZEB market, the project nZEB Ready will act on 3 different pillars as crystallized from literature review and relevant stakeholders’ consultation: awareness, training and support, responding to the critical points of market barriers, as identified in European countries.

The project DivAirCity (H2020-LC-CLA-2020-2) – *“The power of diversity and social inclusion as a mean for reducing air pollution and achieving green urban nexus in climate neutral cities”*- is an ambitious project that aims at shifting the urban paradigm by valuing human diversity (with a focus on gender and multiculturalism) as a resource to define new urban services and models towards cultural-driven green cities. The **project focuses on the urban nexus that combines people, places, peace, economic growth, climate robustness and its impact on Air Quality and Decarbonization**. DivAirCity, through citizen science and creativity will co-design solutions and trace their impact in a transparent and safe way. The project involves *5 EU cities representing replicable case studies: Orvieto (IT), Castellon (SP), Potsdam (D), Aarhus (DK) and Bucharest (RO)*. The consortium represents a mix of stakeholders selected out of the usual only research-focused organizations, to provide a real route-to-market, with the ambition to bring the project outcomes on the market by the end of the project, aiming to revolutionize the concept of urban sustainability.

Considering all these outcomes, the **development plans** are following the same three directions that were the basis of my career: **human comfort and wellbeing, energy-efficient built environment and community sustainability**.

The achieved results sum up an important **drive, creativity, curiosity and a huge team effort** that consolidated my knowledge and scientific abilities to initiate and to run a wide range of research activities in which the **doctoral students can find their own scientific path**.

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