**An Innovative Pathway for PhD research in Thermal Energy Storage**

*January 2018*

*Welcome to the Sixth INPATH-TES Newsletter, which includes the latest on INPATH-TES progress and development, profiles of recently graduated PhDs and of students enrolled in joint PhD supervisions, news updates of conferences and seminars on TES, and a summary of participants of the project. Upcoming conferences is "14th International Conference on Energy Storage – ENERSTOCK 2018", organised by our partner in Çukurova University, Turkey, which will take place on April 25 – 28, 2018 in Adana, Turkey. For further information and updates on INPATH-TES please check our website* www.inpathtes.eu.

## *INPATH-TES Update*

The 7th general meeting of the INPATH-TES project took place at Riga Technical University, Riga, Latvia on September 25th – 26th, 2017. The board meeting was followed by the IMST 2017 conference, which took place at the student campus of Riga Technical University from September 27th- 29th, 2017, where INPATH-TES project coordinator, Prof. Luisa F. Cabeza, presented the main objectives of the INPATH-TES project. Also, the first INPATH-TES student conference "Science or Fiction? – Imagine the future of thermal energy storage technologies and applications" also took place on 29 September 2017 in Riga Technical University.


*INPATH-TES Consortium at Riga Technical University, Latvia during the 7th General Board Meeting, September 2017*

*INPATH-TES Student Conference "Science or Fiction? – Imagine the future of thermal energy storage technologies and applications"September 29th, 2017 at Riga Technical University, Latvia*

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## *INPATH-TES and DEMETRA*

The final workshop of Demetra Project (Design of Mechanical Transmissions: Efficiency, Noise and Durability Optimization) of the call Marie Curie Industry-Academia Partnerships and Pathways (IAPP) took place on November 30th, 2017 in the University of Calabria, Italy. The workshop was organised by Prof. Domenico Mundo (Demetra project coordinator). INPATH-TES project was presented by Prof. Luisa F. Cabeza and Dr. Marilena De Simone. The workshop was an effective opportunity to show the activities and finalities of the INPATH-TES project to the academic and administrative staff of University of Calabria and to create new synergies with similar European experiences in PhD programme implementation. The workshop brought together representatives and experts from different stakeholders: academic researchers from different Universities, research centres, industries, as well as students interested in the PhD programme.


*Prof. Domenico Mundo and Dr. Marilena De Simone, Prof. Luisa F. Cabeza, Dr. Maria C. Trapani, Dr. Francesco Galati*

## *INPATH-TES in the International Conference on Solar Heating and Cooling for Buildings and Industry & Solar World Congress 2017*


Dr. Gabriel Zsembinszki from the INPATH-TES coordinating institution - University of Lleida - presented the project at the SHC 2017: International Conference on Solar Heating and Cooling for Buildings and Industry held together with the ISES Solar World Congress 2017 (SWC 2017) in Abu Dhabi, United Arab Emirates (UAE) from 29 October to 02 November 2017. The joint event, organised by the International Solar Energy Society (ISES), the IEA Solar Heating and Cooling Programme and hosted by the Masdar Institute of Science and Technology, was a good opportunity to connect with the international renewable energy community and learn about the latest in renewable energy developments world-wide.

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***Profiles of INPATH-TES Partners***

## Thermal Energy Storage R&D Group, Çukurova University, Turkey

Cukurova University (CU) has been given the "Research" university title together with 15 other top-most universities in Turkey in 2017. Thermal energy storage R&D group started activities at CU in 1986 with the very first master thesis completed in Turkey on this topic. Since than 10 MSc and 7 PhD theses have been completed. CU joined International Energy Agency Energy Conservation Through Energy Storage (IEA ECES) Technology Collaboration Program in 1995 on behalf of Turkey. Within IEA ECES IA, CU organized several scientific meetings and been active in several Annexes (8, 10, 13, 14, 20, 21, 24, 25, 27, 29, 30, 31) that brought together experts from 18 ECES countries from around the world. CU being the pioneer for introduction of thermal energy storage in Turkey has laboratories equipped with state of the art technologies. Several national and international projects on underground thermal energy storage and phase change materials applications have been completed by thermal energy storage R&D group at CU. Some of the projects are in collaboration with industrial partners from domestic appliances and building material sectors. CU thermal energy storage R&D group with currently 7 PhD and 2 MSc students is continuing to develop innovative thermal energy storage solutions for energy efficient and renewable systems.

*INPATH-TES Partner - Thermal Energy Storage R&D Group, Çukurova University*

## Design and Optimization of Processes and Materials (DIOPMA), University of Barcelona, Spain

The Centre of Design and Optimization of Processes and Materials (DIOPMA) is a scientific research centre at the University of Barcelona, formed at the Department of Materials Science Physical Chemistry and the team is lead by Dr. Josep Maria Chimenos. The group specialises in Materials Science and Engineering, focusing its technological faculties on the fields of Material technologies: materials characterization, advanced material development and production process optimisation, and Energy and environmental technologies: Materials for energy storage, recycling, revalorization and inertization of solid wastes and many more. The group is involved in different European and National projects (Identification of barriers and sustainable opportunities in materials and applications of thermal energy, PhD on Innovation Pathways for TES, New technologies for 3D printing of advanced materials) and several research projects for companies. For more information, please go to www.ub.edu/diopma.

*INPATH-TES Partner - Design and Optimization of Processes and Materials (DIOPMA), University of Barcelona*

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## *Profiles of current INPATH-TES PhD students*

Ms Laura Boquera has enrolled her PhD in October 2017 within co-tutelle between University of Perugia, Italy and University of Lleida, Spain. The title of her thesis is "Multifunctional optimization of concrete as Thermal Energy Storage material". High performance concrete exposed to high temperatures, for applications in thermal energy storage (TES) is investigated. These can be implemented in industry CSP power plants, as well as for buildings fire resistance purposes. (Supervisors in University of Perugia: Prof. Franco Cotana, Dr. Anna Laura Pisello and Supervisors in University of Lleida: Prof. Luisa F. Cabeza, Dr. J. Ramon Castro)

Ms Marta Chàfer has enrolled her PhD in October 2017 within co-tutelle between University of Lleida, Spain and University of Perugia, Italy. The title of her thesis is "Living architecture: The use of building-integrated vegetation technologies for energy savings". The thesis will investigate the potential strategies for building retrofitting according to sustainable criteria to achieve further energy efficiency and environment conditions improvement, through the use of building integrated vegetation solutions (green roofs and green facades). (Supervisors in University of Lleida: Prof. Luisa F. Cabeza, Dr. Gabriel Perez and Supervisors in University of Perugia: Dr. Anna Laura Pisello, Prof. Franco Cotana)

Ms Margalida Fullana Puig has enrolled her PhD in November 2017 within co-tutelle between University of Lleida, Spain and University of Perugia, Italy. The title of her thesis is "Development of sorption materials for thermal energy storage (TES)". The development of sorption or thermochemical materials (TCM) for thermal energy storage (TES) can be an answer to reduce the $CO_2$ emissions and resources depletion contribution of energy and building sectors. This PhD thesis will focus on the characterization of physical and chemical properties to assess its performance; the ascertainment of the reaction efficiency by means of a corrosion, kinetics and cyclability studies; the design and implementation of a new laboratory scale set-up to validate various parameters of the reaction and the modelling and simulation, which will allow to easily change variables and to check their effects on the system. (Supervisors in University of Lleida: Prof. Luisa F. Cabeza, Dr. Aran Solé – Universitat Jaume I, and Supervisors in University of Perugia: Dr. Anna Laura Pisello, Prof. Franco Cotana)

Mr Joan Tarragona has enrolled his PhD in November 2017 within co-tutelle between University of Lleida, Spain and University of Perugia, Italy. The title of his thesis is "Smart control techniques for Thermal Energy Storage (TES) systems". There is a mismatching between energy generation and consumption, consequently the energy storage plays an important role to solve that problem. Additionally, to control the operation of heating and cooling systems either in domestic or in office schedule is strongly important. In that sense, the smart control techniques are a key point to reduce electricity cost at user and grid operator level. The main goal of the thesis will be to couple thermal energy storage (TES) concepts with a model predictive control strategy in order to analyse its behaviour on a real prototype. (Supervisors in University of Lleida: Prof. Luisa F. Cabeza, Dr. Cèsar Fernández, Dr. Alvaro de Gracia and Supervisors in University of Perugia: Dr. Anna Laura Pisello)

Ms Elena Olacia has enrolled her PhD in November 2017 within co-tutelle between University of Lleida, Spain and University of Perugia, Italy. The title of her thesis is "Development and multi-physics optimization of bio-based materials for building envelopes". The PhD thesis will be focused on the use of biomass by-products to generate building materials, improving the overall energy performance of the building (Supervisors in University of Lleida: Prof. Luisa F. Cabeza, Dr. Gabriel Pérez and Supervisors in University of Perugia: Prof. Franco Cotana, Dr. Anna Laura Pisello)

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## *Profiles of PhD Graduates*

Dr. Veronica Lucia Castaldo was awarded her PhD in April 2017 from University of Perugia, Italy. The title of her thesis was “Thermal-energy performance of buildings in urban area: an innovative approach for bridging the gap between single-building and inter-building scale”. Currently, the available tools for predicting buildings thermal-energy performance in urban environments do not take into account the impact of the local boundary conditions such as the surrounding built area and local microclimate phenomena. Within this context, the non-negligible effect of such local boundary conditions was quantified by enlarging the perspective of the analysis from the single-building to the inter-building scale. The results revealed that the shift of the perspective to take into consideration the mutual impact of local boundaries allows to enhance both the buildings and districts energy efficiency by exploiting the benefits generated by the larger scale. (Supervisors: Prof. Franco Cotana, Prof. Anna Laura Pisello)

Dr. Huaichen Zhang was awarded his PhD in February 2017 from Eindhoven University of Technology, the Netherlands. The title of his thesis was "On sugar alcohol based heat storage materials: a nanoscale study and beyond". In his thesis, a multiscale model is built to study the phase change properties of sugar alcohols - a novel material for heat storage in the built environment. The thesis takes a fundamental look at the nanoscale heat transfer in sugar alcohol - carbon nanocomposites, and studied the nucleation and crystallization behavior of sugar alcohols. Using molecular dynamics simulations, a set of previously unknown thermodynamic properties are obtained. (Supervisors: Prof. David Smeulders and Dr. Silvia V. Nedea, Dr. Camilo Rindt)

Dr. Mohammadreza Gaeini was awarded his PhD in July 2017 from Eindhoven University of Technology, the Netherlands. The title of his thesis was "Thermochemical seasonal heat storage for the built environment: a multi-scale investigation". In his work, a multi-scale approach is effectively used to investigate the thermochemical heat storage for the built environment. The technological maturity on thermochemical heat storage concept is improved on three levels: material, reactor and system. Studies were performed to improve stability, kinetics and energy density of the material. A robust reactor design is achieved based on the detailed description of the transport phenomena occurring in the reactor. The system is improved by implementing a heat recovery unit. Finally, a prototype with an energy capacity of about 50 kWh is built, to demonstrate that thermochemical heat storage is a realistic and viable option for application in the built environment. (Supervisors: Prof. Herbert Zondag, Prof. David Smeulders, Dr. Camilo Rindt)

Dr. Joana Andrade was awarded her PhD in July 2017 from University of Minho, Portugal. The title of her thesis was ‘Early Stage design methodology to ensure life cycle sustainability of residential buildings’. Research shows that if sustainability goals are established during early design stages, against which to assess options of achievement, the success of accomplishing a sustainable building, increases. Her thesis proposed a new methodology – EasyMode – aimed at supporting early design phases decisions towards sustainable design. EasyMode was intended to be easy and practical to use, so practitioners can make quick and expedite analysis, providing guidelines and concepts regarding the three sustainability cornerstones. To each sustainability indicator evaluated, the tool allows different solutions to be tested and compared, enabling selecting the best solution and setting performance targets to accomplish during design. This works endows designers with sustainability concepts in an easy manner, improving their knowledge on the subject and thus, improving their projects sustainability. (Supervisor: Prof. Luís Bragança)

Dr. Amar Deep Pathak was awarded his PhD in September 2017 from Eindhoven University of Technology, the Netherlands. The title of his thesis was "multi-scale modelling of thermo-chemical materials for seasonal heat storage applications**".** He has developed a reactive force-field for MgCl2 hydrates and performed DFT calculations to study these materials.
(Supervisors: Prof. David Smeulders and Dr. Silvia V. Nedea, Dr. Camilo Rindt)

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***Profiles of PhD Graduates***

Dr. Joaquim Romaní Picas was awarded his PhD in November 2017 from University of Lleida, Spain. The title of his thesis was "Improvement of building energy efficiency with radiant walls". The radiant walls actively use the big surfaces and thermal mass of buildings, allowing for peak load shifting and low temperature gradient heating and cooling, which eases the integration of renewable energies. Experimental and simulation data was used to assess the radiant capabilities and control strategies. His other research area of interest involves: Heating and cooling, building energy efficiency, thermal energy storage, renewable energies. (Supervisors: Prof. Dr. Luisa F. Cabeza, Dr. Alvaro de Gracia)

Dr. Mohammad Saffari was awarded his PhD in November 2017 from University of Lleida, Spain. The title of his thesis was "Simulation-based optimization of thermal energy storage (TES) materials for building and industry applications". Thermal energy storage (TES) technology is a key element in all energy scenarios. The significant original contribution emerged from this PhD thesis is the use of simulation and optimization methods to advance the application of TES technology in the industry and building sectors. His other research area of interest involves: Phase change materials, building physics, renewable energy, green buildings, passive cooling and heating, natural ventilation, thermal comfort, energy management, dynamic energy modelling, concrete technology.
(Supervisors: Prof. Dr. Luisa F. Cabeza, Dr. Alvaro de Gracia)

Universitat de Lleida
Universitat de Barcelona
fpU Putting built environment USERS first, for a smarter, sustainable future User feedback program
Ulster University
Çukurova University 1973
Trinity College Dublin Coláiste na Tríonóide, Baile Átha Cliath The University of Dublin
Università degli Studi di Perugia
Università della Calabria
INSA Institut National des Sciences Appliquées Lyon
Ben-Gurion University of the Negev
1862 Rīgas Tehniskā Universitāte
Universidade do Minho
Ghent University
AIT Austrian Institute of Technology
TU/e Technische Universiteit Eindhoven University of Technology
arçelik
LAIF
cnrs
eit InnoEnergy Knowledge Innovation Community
DLR
ABENGOA SOLAR

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