



# Program Book

International Conference on

**MATERIALS**

**& ENERGY**



Hammamet, Tunisia.

April 23-26, 2019.

**ICOME'19**

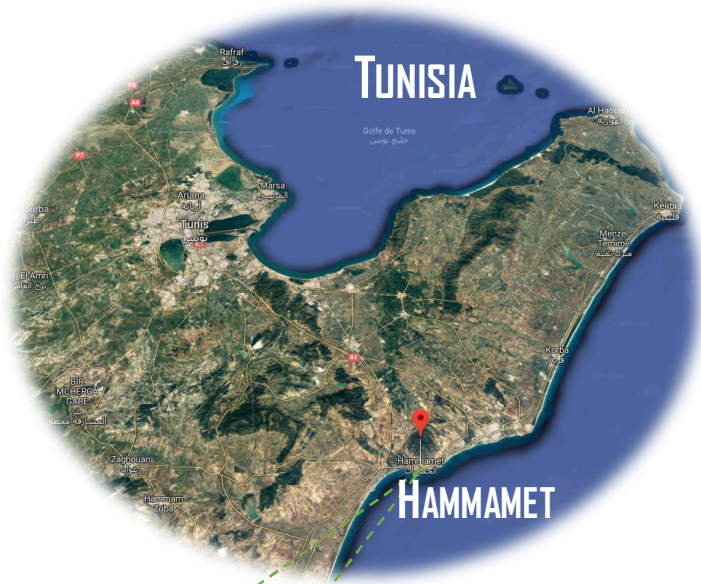


**Location of ICOMÉ'19**



**International Delegates**

**ICOMÉ'19 INTERNATIONAL CONTRIBUTORS**



## ICOME'19 LOCATION

Golden Tulip Taj Sultan Resort - Hammamet-



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# WELCOME

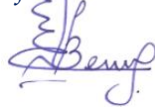
*After the great success of the International Conference on Materials & Energy (ICOME'15) in the nice Mediterranean city Martil-Tetouan / Morocco, followed by another edition in 2016 within the beautiful Atlantic city of La Rochelle / France, the edition 2017 into the beautiful Eastern part of China at Tianjin, and finally the ICOMÉ'18 in the coastal city Donostia-San Sebastian which located at the North of Spain, ICOMÉ'19 will move to Hammamet / Tunisia. This edition is jointly organized with French University of Picardie Jules Verne, and Tunisian University of Tunis El Manar.*

*ICOME'19 Conference still a meeting which dedicated to cutting edge research that addresses scientific needs of academic researchers, industrials and professionals to explore new horizons of knowledge on various topics in interlink between materials & energy application fields. The conference will host a Topical School for PhD students and various specific symposiums as well. ICOMÉ'19 is scheduled to include high quality contributions during the presentation sessions, and to engage participants in interesting discussion sessions.*

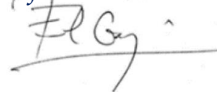
*The ICOMÉ Series' Chairs Pr. R. Bennacer (ENS-Cachan) and Pr. M. El-Ganaoui (University of Lorraine), and the local ICOMÉ'19 Chairs Pr. E. Seddiki (University of Tunis EL Manar) and Pr. H. Beji (University of Picardie Jules Verne), hope that everyone will find an important topic of interest through the ICOMÉ meeting, as well as the great pleasure in exchanging with both communities of materials and energy.*

## GENERAL ICOMÉ SERIES' CHAIRS

Prof. R. Bennacer



Prof. M. El-Ganaoui



## LOCAL CHAIRS ICOMÉ'19

Prof. E. Seddiki



Prof. H. Beji



# BIENVENUE

*Après le succès de la Conférence internationale sur les matériaux et l'énergie ICOMÉ'15 dans la magnifique ville méditerranéenne de Martil-Tétouan au Maroc, suivie de l'édition 2016 dans la belle ville atlantique de La Rochelle / France, puis de l'édition 2017 à Tianjin à l'est de la Chine avec son charme oriental, et ensuite à Donostia-Saint Sébastien, ville côtière située au nord de l'Espagne, ICOMÉ'19 se déroulera à Hammamet sur la côte méditerranéenne en Tunisie. Cette édition est organisée conjointement avec l'Université française de Picardie Jules Verne et l'Université tunisienne de Tunis el Manar.*

*ICOMÉ'19 est une rencontre dédiée à la recherche de pointe qui répond aux besoins scientifiques des chercheurs universitaires, des industriels et des professionnels, en vue d'explorer de nouveaux horizons de connaissances sur divers sujets liés aux domaines des matériaux et de l'énergie. La conférence accueillera une Ecole Thématique et des colloques spécifiques.*

*ICOMÉ, a cultivé la tradition d'inclure des contributions de haute qualité lors des sessions orales, et d'engager les participants dans des sessions de discussion intéressantes.*

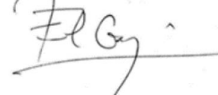
*Les chairmans de la série ICOMÉ Pr. R. Bennacer (ENS Cachan) et Pr. M. El-Ganaoui (Université de Lorraine), et les chairmans locaux de la version ICOMÉ'19 Pr. E. Seddiki (Université de Tunis EL Manar) et Pr. H. Beji (Université de Picardie Jules Verne) espèrent que tout le monde trouvera dans cette manifestation des sujets d'intérêt, et un grand plaisir à échanger avec les communautés de matériaux et d'énergie.*

## CHAIRMANS DE LA SERIE ICOMÉ

Pr. R. Bennacer



Pr. M. El-Ganaoui



## CHAIRMANS LOCAUX

Pr. E. Seddiki



Pr. H. Beji



# مرحبا

بعد نجاح المؤتمر الدولي حول المواد والطاقة ICOMÉ'15 في مدينة مرتيل المتوسطية الرائعة ، تليها نسخة 2016 في مدينة لاروشيل الأطلسية الجميلة في فرنسا ، ثم نسخة 2017 في تيانجين في الصين بسحرها الشرقي، وأخيرا في دونوستيا / سان سيباستيان المطلة على المحيط الأطلسي في شمال إسبانيا سنة 2018، سوف تعقد نسخة 2019 على ضفاف المتوسط بمدينة الحمامات التونسية. تم تنظيم هذه الدورة بالتنسيق مع جامعة بيكاردي جول فيرن الفرنسية وجامعة تونس المنار.

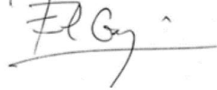
ICOMÉ'19 هو مؤتمر مخصص للبحوث المبتكرة التي تلبي الاحتياجات العلمية للباحثين في الجامعات والصناعة والمهنيين لاستكشاف آفاق جديدة من المعرفة حول مختلف المواضيع المتعلقة بالتطبيقات والابتكارات في مجالات المواد وتكنولوجيا الطاقة. يستضيف المؤتمر مدارس وندوات متخصصة.

من تقاليد المؤتمر الحرص على المساهمات عالية الجودة خلال العروض الشفوية، وإشراك الحاضرين في جلسات نقاش ممتعة.

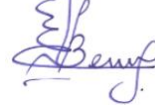
رؤساء سلسلة ICOMÉ ، أ. رشيد بن ناصر (من جامعة Cachan) و أ. محمد الكناوي (من جامعة Lorraine) والرؤساء المحليون لنسخة 2019 أ. عز الدين الصديقي من جامعة تونس المنار و أ. حسن الباجي من جامعة بيكاردي جول فارن الفرنسية يرجون أن يجد الجميع في هذا الحدث مواضيع ذات أهمية ، ويسعدهم للغاية أن يشتكوا في نقاشها مع مجتمعي المواد والطاقة.

## رؤساء السلسلة

أ. محمد الكناوي



أ. رشيد بن ناصر



## الرؤساء المحليون

أ. حسن الباجي



أ. عز الدين الصديقي



# FOREWORD

*Extraction, manipulation, transformation and conversion are words that can characterize materials & energy. Indeed, their history is a version of the history of humanity that is expressed by their use in times of peace and war. Civilizations evolve in a manner intimately linked to the mastery of materials and energy.*

*Such coupled concepts have faith evolved in a complementary way between artisan and engineer. Between tests and concept, this coupling has progressed rapidly in a short time to explore new sources of energy and to communicate to the world an unsuspected dimension of comfort, mobility, communication influencing up to social codes and the relationship to nature. With each mutation sociology, habits and behaviors are deeply modified.*

*The industrial revolution through the binomial coal / steam boosts, the use of materials and encourages technical innovations that accompanied by intense research into energy resources have achieved the development of electricity and nuclear energy. Until now, the adoption of fossil fuels represents more than 80% of their availability, which requires an urgent energy transition that will be possible thanks to citizen participation in political orientations. The search for an efficient and rational use of energy is transferred to the fields of knowledge and research, being a subject of concern for the citizen throughout the world.*

*Consequently, by different ways of exploration into various cultures, abstraction is reached at different schools of thought and cultures that at first sight seem diametrically opposed. The Mediterranean basin is not far behind and has played a very important role in this evolution.*

*Common sense is closely tied to the history of materials and energy, a simple observation of a knitter can inspire innovation in an aircraft fuselage or a simple observation of a flame can inspire the innovation in a rocket booster.*

*The association of the materials and energy was originally only to provide facilities for daily use, to allow life on earth. The exploration and mastery of the infinitely small has led to a mastery of new products with unsuspected properties and wide potential in the energy field. The last decades are more geared towards functionalities and environmental control, where leisure and recreation are the second most important necessities of life such as food and housing.*

*From the genius of Archimedes to the deception of the philosopher' stone, or the last unlimited perpetual movement have been achieved by the use of materials and energy. From the imaginary projects of Jules Verne to the mathematical mastery of aeronautics by Von Karman, materials and energy have evolved between science, imagination and fiction.*



*The human being has always instinctively proceeded in the use of matter & energy to understand, use, store and control the use of materials and energy in their daily lives & perpetuate their species.*

*The scientist will observe, understand, quantify and predict while the engineer will find, transform, create and use. This gear has allowed molding the development of modern science creating a close link between disciplines such as Mathematics, Mechanics, Chemistry and Physics. All this justifies the dedication of an international periodical edition to the topic of Materials & Energy (ICOME series).*

*The International Conference on Materials & Energy (ICOME) continues to travel around coastal cities and major basins of civilization: Tetouan-Martil (Moroccan coast), La Rochelle (French coast), Tianjin (Chinese side), San Sebastian (Spanish Basque coast), and Hammet (Mediterranean Tunisian coast).*

*The combination of wood and combustion played a vital role in meeting the needs of the societies up to the domination of the coal / steam and then, the nuclear / electricity pair. Wood is experiencing a growing interest in the environment and Eco-sustainable approaches. The wood material is an important theme of the ICOMÉ series. This goes from the field of construction & sustainable building until the design of Eco-materials with low environmental impact to the recovery of waste and by-products to the synthesis of biomaterials & bioenergy. The edition also includes life cycle analysis and environmental cost estimates.*

*The biggest challenge regarding the constructability of buildings is the demand for energy, innovative systems for conditioning the atmosphere or the integration of renewable energy production in housing. The speakers include international specialists in the areas of renewable and alternative energy, energy in construction and structural sustainability, as well as biomass.*

*The series of Conferences on Materials & Energy is a promoter of the initiatives of young researchers, in the first place for the recognition and realization of the importance of the event and then, for training that takes place in it. As always, a thematic school will benefit from the presence of international speakers as in previous editions. All these initiatives have allowed settling the foundations of the pyramid of knowledge allowing many to accelerate his progress towards progress. Innovation, the socio-economic cost, the difference of points of view, the ethics ... so much quality that accompany the scientist in his quest for truth.*

*In this sense, the wink to the universal scientist Averroes through the award reinforces this vision of a man who puts the truth beyond the beliefs and allegiances of his time, the intelligence beyond the interest of use:*

*“There are vulgar conceptions quite sufficient for practical life; they must even be the food of men. They are not enough, however, for intelligence ”*

*” The knowledge acquired in a foreign country can be a fatherland and ignorance can be an exile lived in one's own country. ”*

*Averroes (1126-1198)*

*The conference chairs thanks the international scientific committee, the operational technical committee and the high quality reviewing and helping on having high quality current technical content and also to explore new knowledge horizons on a variety of topics interconnected with fields of application in Materials & Energy.*

*Also the organizing committee and staff of the Universities for the preparation of this event are greatly acknowledged. We hope that everyone will find an important topical interest, a great pleasure in exchanging with the both community of materials & energy and to enlarge the discussion towards: architects, industrial, and decision makers in societies dreaming with the city of the future.*

*Prof. R. Bennacer & Prof. M. El-Ganaoui*

# AVANT-PROPOS

*L'extraction, la manipulation, la transformation et la conversion sont des mots qui peuvent caractériser les matériaux et l'énergie. En effet, leur histoire est une autre version de l'histoire de l'humanité s'exprimant par leur utilisation en temps de guerre et de paix. Les civilisations évoluent de manière intimement liée à la maîtrise des matériaux et de l'énergie. Ces concepts ont évolué de manière complémentaire entre l'artisan et l'ingénieur. Entre tests et fondamentaux, ce couplage entre matériaux et énergie a rapidement progressé pour explorer de nouvelles sources d'énergie et communiquer au monde une dimension insoupçonnée de confort, de mobilité, de communication influençant jusqu'aux codes sociaux profonds et au rapport anthropique à la nature. À chaque mutation sociologique, les habitudes et les comportements des civilisations sont profondément modifiés.*

*La révolution industrielle à travers la dualité charbon - vapeur stimula l'utilisation de matériaux et encouragea les innovations techniques associées à une recherche intensive dans les ressources énergétiques. Cette recherche a permis par la suite le développement de l'électricité et de l'énergie nucléaire. Jusqu'à présent, l'utilisation des combustibles fossiles représenterait plus de 80% de l'ensemble des énergies, ce qui nécessite une transition énergétique urgente qui ne peut être possible que grâce à la participation des citoyens et aux orientations politiques. Le domaine d'une utilisation rationnelle de l'énergie dépasse aujourd'hui la simple exploitation, et est transféré aux domaines de la connaissance et de la recherche scientifique de pointe, ce qui constitue un sujet de préoccupation pour les citoyens du monde. Historiquement, dans différentes cultures et écoles de pensées, qui semblent à première vue diamétralement opposées, l'abstraction est atteinte par différentes méthodes d'exploration. Le bassin méditerranéen a toujours été un pionnier, et a joué un rôle important dans cette évolution.*

*Le sens commun a toujours été étroitement lié à l'histoire des matériaux et de l'énergie. Une simple observation d'un tricoteur peut inspirer l'innovation dans le fuselage d'un avion ou une simple observation d'une flamme peut inspirer l'innovation dans un propulseur de fusée.*

*L'association des matériaux et de l'énergie visait à l'origine uniquement à fournir des installations d'utilisation quotidienne, permettant la vie sur terre. Avec les avancées scientifiques, l'exploration et la maîtrise de l'infiniment petit ont conduit à la maîtrise de nouveaux produits aux propriétés insoupçonnées et au potentiel important dans le domaine de l'énergie. Les dernières décennies sont davantage axées sur les fonctionnalités et le contrôle de l'environnement, où les loisirs sont la seconde nécessité de la vie, au même égard que la nourriture et le logement.*

*Du génie d'Archimède à la déception de la pierre philosophale ou au dernier mouvement perpétuel ont été réalisés par l'utilisation de matériaux et d'énergie. Des projets imaginaires*

*de Jules Verne à la maîtrise mathématique de l'aéronautique par Von Karman, matériaux et énergie ont évolué entre science, imagination et fiction. L'être humain a toujours procédé instinctivement à l'utilisation de la matière et de l'énergie pour comprendre, utiliser, stocker et contrôler l'utilisation des matériaux et de l'énergie dans sa vie quotidienne et perpétuer son espèce. Le scientifique observera, comprendra, quantifiera et essaye de prévoir pendant que l'ingénieur trouvera, transformera, créera et utilisera. Cette dualité a permis de modeler le développement de la science moderne en créant un lien étroit entre des disciplines telles que les mathématiques, la mécanique, la chimie et la physique.*

*Tout cela justifie la création d'une édition périodique internationale au thème Matériaux et Energie (série ICOMÉ). La Conférence internationale des matériaux et de l'énergie (ICOMÉ) continue de sillonner les villes côtières et les principaux bassins de la civilisation: Tétouan-Martil (côte marocaine méditerranéenne), La Rochelle (côte atlantique française), Tianjin (côte pacifique chinoise), Saint-Sébastien (côte basque espagnole), et Hammet (côte tunisienne).*

*La combinaison du bois et de la combustion a joué un rôle vital dans la satisfaction des besoins des sociétés jusqu'à la domination du couple charbon / vapeur, puis nucléaire / électricité. Le bois connaît un intérêt croissant pour l'environnement et les approches éco-durables. Le bois est un thème important de la série ICOMÉ. Cela va du domaine de la construction et de la construction durable jusqu'à la conception d'éco-matériaux à faible impact environnemental jusqu'à la valorisation des déchets et des sous-produits, en passant par la biomasse. Le plus grand défi en ce qui concerne la constructibilité des bâtiments est la demande en énergie, des systèmes innovants de conditionnement de l'atmosphère ou l'intégration de la production d'énergie renouvelable dans le logement. Parmi les intervenants figurent des spécialistes internationaux des domaines des énergies renouvelables et alternatives, de la construction et de la durabilité structurelle, ainsi que des processus physico-chimiques de transformation du bois, de l'énergie et des bioraffineries.*

*La série de conférences sur les matériaux et l'énergie promeut les initiatives de jeunes chercheurs, en premier lieu pour la reconnaissance et la réalisation de l'importance de l'événement, puis pour la formation qui y est dispensée. En bref, une école thématique qui bénéficiera de la présence de conférenciers internationaux comme dans les éditions précédentes. Toutes ces initiatives ont permis de poser les fondements de la pyramide du savoir permettant à l'homme d'accélérer ses progrès vers le progrès. L'innovation, le coût socio-économique, la différence de points de vue, l'éthique ... autant de qualités qui accompagnent le scientifique dans sa quête de vérité. En ce sens, le clin d'œil au scientifique universel Averroès à travers le prix portant son nom renforce cette vision d'un homme qui place la vérité au-delà des croyances et des allégeances de son temps, l'intelligence au-delà de l'intérêt de l'utilisation:*

*« Il y a des conceptions vulgaires assez suffisantes pour la vie pratique; ils doivent même être la nourriture des hommes. Ils ne suffisent cependant pas à l'intelligence »*

*« Les connaissances acquises dans un pays étranger peuvent être une patrie et l'ignorance peut être un exil vécu dans son propre pays. »*

*Queroès (1126-1198)*

Les présidents de la conférence remercient le comité scientifique international, le comité technique opérationnel et la grande qualité de la révision et de la qualité du contenu technique ainsi que de l'exploration de nouveaux horizons de connaissances sur une variété de sujets liés aux domaines d'application des matériaux et de l'énergie.

Le comité organisateur et le personnel des universités pour la préparation de cet événement sont également grandement remerciés. Nous espérons que chacun trouvera dans ce congrès un intérêt important et d'actualité, un grand plaisir à échanger avec la communauté des matériaux et de l'énergie et à élargir le débat aux: architectes, industriels et décideurs de sociétés rêvant de la ville de la futur.

Pr. R. Bennacer & Pr. M. El-Ganaoui

## مقدمة

الاستخراج والمعالجة والتحويل هي كلمات يمكن أن تميز المواد والطاقة. في الواقع إن تاريخها هو نسخة من تاريخ الإنسانية الذي يتم التعبير عنه من خلال استخدامهما في أوقات الحرب والسلام. إن الحضارات تتطور بطريقة مرتبطة ارتباطاً وثيقاً بإتقان المواد والطاقة. هذه المفاهيم المزدوجة تطورت بطريقة تكاملية بين الحرفي والمهندس. بين الاختبار والفهم، تقدم هذا الاقتتان بسرعة في وقت قصير لاستكشاف مصادر جديدة للطاقة والتواصل مع العالم وقطع بعداً غير متوقع من تحويل طريقة التنقل والتواصل و الرفاهة مما يؤثر على الرموز الاجتماعية وعلاقة الإنسان بالطبيعة.

لقد ارتكزت الثورة الصناعية على ثنائية الفحم والبخار وهو أمر ذو حدين بسبب التلوث الشديد الي يمثلته استخدام الفحم ثم مكن تشجيع الإبتكارات التقنية المصنوعة بالأبحاث المكثفة في الموارد والطاقة من تطوير الكهرباء والطاقة النووية. و لكن حتى الآن ، يمثل استخدام الوقود الأحفوري أكثر من 80 % ، الأمر الذي يتطلب انتقالاً عاجلاً في طريقه استخدام الطاقة وهذا لن يكون ممكناً إلا بفضل مشاركة المواطنين في التوجهات السياسية و في الإختيارات الاستهلاكية. إن البحث عن استخدام فعال ومقتلبي للطاقة انتقل اليوم من الإستعمال الحرفي إلى مجالات المعرفة المعمقة والبحث العلمي لكونه موضع اهتمام المواطن في جميع أنحاء العالم. و بهذه الطريقة أدى إختلاف طرق الاستكشاف في مختلف الثقافات، إلى الوصول إلى درجة التجريد في مدارس فكرية وثقافات تبدو للوهلة الأولى متعارضة تماماً. و لقد حضيض حضارات حوض البحر الأبيض المتوسط بدور مهم في هذا التطور. من جهة أخرى ارتبط التطور العقلاني ارتباطاً وثيقاً بتاريخ المواد والطاقة ، إذ يمكن أن تؤدي الملاحظة البسيطة في عمل النسيج إلى إبتكار محظوم في صنع جسم الطائرة أو أن تؤدي الملاحظة البسيطة لإشتعال النار إلى تطوير نفائذ اللصب في الصواريخ. في العصور الأولى للإنسانية كانت المواد والطاقة تستعمل فقط لتوفير مرافق للاستخدام اليومي من أجل البقاء على قيد الحياة، ثم أدى استكشاف الذرة وإتقان الصغوالانهازي إلى إتقان منتجات جديدة ذات خصائص غير متوقعة وإمكانات واسعة في مجال الطاقة. أما الآن فتتجه العقود الأخيرة نحو التحكم في المحيط من أجل خلق رفاهية أكبر للإنسان إذ تعد اليوم أوقات الفراغ والترفيه ثابتي أهم ضرورات الحياة.

بين عبقرية أرخميدس و الإبحاط الذي أوقعته أسطورة الحجر الفلسفي و بين الأنظمة ذات الحركة غير المحدودة التي تم تحقيقها من خلال استخدام المواد والطاقة، إلى المشاريع الخيالية لجول فيرون الإبتقان الرياضي في علم الطيران لفنون كارمان، تطورت المواد والطاقة بين العلم والخيال. ولقد بدأ الإنسان تحريزياً في حياته اليومية في استخدام المادة والطاقة من أجل فهمها واستخدامها وتخزينها والتحكم فيها. أما اليوم فإن الصلة الوثيقة بين التخصصات مثل الرياضيات والميكانيكا والكيمياء والفيزياء أدت إلى ثورة في الفهم والإتقان،

وحيث يقوم العالم بمراقبة وفهم وقياس وتوقع ما قد يحدث سيد المهندس سبباً لتحويل المواد وخلق أفق جديد لإستخدام المواد والطاقة. وقد سمع هذا العناد بإنتاج تطور غير مسبوق في العلوم الحديثة.

كل هذا يبرر العرس على إصدار مؤتمر دولي لموضوع المواد والطاقة (سلسلة ICOMÉ). وهذا يواصل المؤتمر الدولي للمواد والطاقة (ICOMÉ) السفر حول المدن الساحلية والأحواض الرئيسية للحضارة : تطوان - مرتيل (الساحل المغربي المتوسطي) ، لاروشيل (الساحل الأطلسي الفرنسي) ، تيانجين (ساحل المحيط الهادي الصيني) ، سان سيباستيان (ساحل الباسك الإسباني) والعمامة (ساحل تونس الشرقي).

سلسلة المؤتمرات حول المواد والطاقة هي من المبادرات التي تهتم بالباحثين الشباب، و تهدف في المقام الأول للتوعية بأهمية البحث وإدراكه، ثم تهتم في المقام الثاني بالتكوين المنهجي للباحثين الشباب من خلال مدرسة موضوعية ستستفيد من وجود خبراء و مختصين دوليين. كل هذه المبادرات سمحت بوضع أسس هرم المعرفة مما يسمح للإنسان بتسريع تقدمه نحو التقدم و الابتكار و التميز الاجتماعي والاقتصادي على اختلاف وجهات النظر وكل هذه وسائل قيمة تصاحب العالم في بحثه عن الحقيقة.

وبهذا المعنى ، فإننا نخص تكريماً لابن رشد من خلال الجائزة التي تحمل اسمه و التي تُهدى إلى أحسن البحوث في المؤتمر. ولقد اخترنا ابن رشد لأنه رجل يضع الحقيقة فوق معتقدات زمانه وولاءات أهل عصره.

هناك معارف بسيطة كافية للحياة قد تبلغ حتى صنع طعام الإنسان لكنها ليست كافية للعلم.

يمكن أن يكون البلد الغريب الذي فيه معرفة مكتسبة موطناً، ويمكن أن يكون الجاهل تحريماً في بلده.

ابن رشد (1126-1198)

يشكر رؤساء المؤتمر اللجنة العلمية الدولية واللجنة الفنية و لجنة المراجعة عالية الجودة على مجهود الرامي إلى الحصول على مؤتمر عالي الجودة. كما يشكرون جليل الشكر اللجنة المنظمة لقيامهم بإعداد هذا الحدث. نأمل أن يجد الجميع في هذا المؤتمر اهتماماً موضوعياً مهماً، وسروراً كبيراً في التبادل مع مجتمع المواد والطاقة. كنا نأمل أن يتوسع النقاش إلى المهندسين المعماريين والصناعيين وصناع القرار في المجتمعات التي تحلم بمدينة مستقبل.

أ. رشيد بن ناصر و أ. محمد الكناوي

Translation to Arabic by Dr. H. Ben Hamed

# HOW TO REACH THE CONFERENCE

## *Travelling by Plane*

The nearest airport to Hammamet is the International Tunis Carthage airport. The distance from the airport to the hotel is about 75 km.

- The easiest way to travel from the airport to Hammamet is to take a taxi from the airport to the hotel Hammamet. It costs around 40€. The reservation and details can be found on the webpage <http://www.transfert-aeroport-tunis.com/en/>, and <http://www.taxi-tunisie.net>.
- There are also bus shuttles from the airport to Hammamet. The bus costs around 12€. Then you have to take a local taxi from the bus station to the hotel it costs about 3€. Timetable is available at: <https://www.holidaytaxis.com/fr/>.
- You can also take a taxi to the train station, then take the train to Hammamet, and take a taxi again to the hotel. The total cost is about 20€.



## *Travelling by Car*

The city is connected to the rest of Tunisia by the A-1 (Tunis-Hammamet-Monastir highway). GPS is available in Tunisia. Just put Golden Tulip Resort Hammamet as destination on Google maps.



# ICOME SERIES CHAIRS



*Pr. Dr. Ing. R. Bennacer is an Engineer in Mechanical field (1989), and he got his PhD thesis at Pierre & Marie Curie University (Paris 6) in 1993. He worked as lecturer in the University Paris XI (1993/94), became an associate professor at Cergy Pontoise University in 1994 and full Professor in 2008. He moved as senior Professor to the prestigious school Ecole Normale Supérieure (Paris-Saclay) since 2010. He becomes an Exceptional National Class Professor since 2017. He is also adjunct professor at Tianjin Uni. Of comm. (China) and UMB Univ.*

*He assumed several responsibilities, director of the LEEVAM research team (2003-2007), Licence degrees (2008-2010), Aggregation title (2010-2011), Master research degree (2011-2013), Transfer and Environmental Research Unit (CNRS LMT-Lab) (since July 2012) and dean of Civil/Environmental department (Oct. 2012/Sep. 2016). His present research activity is within the LMT laboratory where he manages Transfer and Environmental Research Unit. His Research field covers wide spectrum and several domains. It covers the building material for energy applications or on durability aspect, renewable and energy system. The expertise covers the direct numerical simulation including CFD coupling on multi-scales. The previous approach is consolidated by analytical or reduction approach in order to identify the instabilities and global behavior bifurcation and similarity controlling parameters in multiphysics situations. He published around 10 book chapters and more than 150 referenced international journals (Rank A).*



*Pr. M. El-Ganaoui is a full professor at the University of Lorraine and researcher in the Jacques Villiermaux Federation for mechanics, energy and processes (FR 28 63/LERMAB). He is heading the research in energy in the Henri Poincaré Institute of Technology in Longwy. Previously, he was an Ass. Professor in the University of Limoges and the SPCTS UMR 6638 CNRS laboratory where he was responsible for the Physics Department (2004-2010) and the international cooperation*

*service (2006- 2010) in the Faculty of science and technology. His research aims to understand heat and mass transfers through modeling and numerical simulation with a specific activity in the field of the solid -liquid-vapor phase change. Applications concern materials and energy and benefit to energy systems including phenomena for sustainable building (Eco-materials). He teaches the mechanics of continuous media, heat transfers, and numerical methods. He was advisor of more than 25 Phd Thesis with strong international interaction noticeably in the Euro-Mediterranean context. He participated/managed the PAI Australia, Canada, Maghreb (Tassili, Utique, Volubilis), China (Xugangqi).*

*El Ganaoui has participated in the Edition of more than 10 special issues and conference proceedings, co-authored over than 200 publications in journals (rank A) and participated in more than 100 international conferences including ten he co-organized. He is member of many international scientific societies in mechanics and heat transfers.*

## LOCAL ICOMÉ'19 CHAIRS



***Pr. Ezedine SEDIKI** is Full Professor of Physics at the Faculty of Science of Tunis since 2002, PhD (Doctorat d'Etat) from the University of Tunis El Manar, Tunisia. Visiting scholar at the Universities in France, Germany, Canada, and Portugal. He authored and co authored several articles on Numerical Fluid Mechanics and Heat Transfer, Thermal Radiation, and Radiative Properties of Gaz. His current research focus is on studying Transport Phenomena by using Lattice Boltzmann Method. He supervised more than ten PhD in Physics. He served as Head of Thermal Radiation laboratory and as General Director of the Doctoral School of Faculty of Tunis (2012-2016). He is also a very active member of the Tunisian Physical Society as a Vice President (2010-2014).*



***Pr. Hassen BEJI** is full professor of Physics at the University of Picardy Jules Verne. He is in the head of the Laboratory of Innovative Technologies since 2011. He is the author of tens of international publications on fluid dynamics, material, sustainable construction, and concrete properties. Pr. Beji supervised more than thirty PhD in Physics and engineering, especially in active collaboration with southern country and he participates in more than twenty international projects.*

# COMMITTEES

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***Prof. Amen-Allah GUIZANI** : Professor of Physics at the Center of Research and Technologies of Energy since 2005. He is the Director of the Laboratory of Thermal Processes. His research activities focus on renewable energies and simulation of thermal processes. He has published more than 90 articles and is actively involved in international research projects related to renewable energy applications. Prof. Guizani has supervised more than 20 Doctoral Thesis in Physics.*



***Prof. Afif El-CAFSI** : Professor of physics at the Faculty of Sciences of Tunis-University of Tunis El Manar. He holds a PhD in Fluid Mechanics. Afif El Cafsi is currently Director of the LETTM Thermal and Thermal Energy and Transfer Laboratory. He is the author of at least 60 publications in the field of thermal flows and transfers.*



***Dr. Haïkel BEN HAMED** : Associate Professor of Physics at the University of Picardy Jules Verne, in France. He is Member of the Laboratory of Innovative Technologies. His research activities focus on numerical computational dynamics, and linear and weakly nonlinear stability analysis, on convective and absolute instabilities of viscoelastic, and power-law non-Newtonian fluids. He has published tens of articles and supervised eight PHD in Physics.*



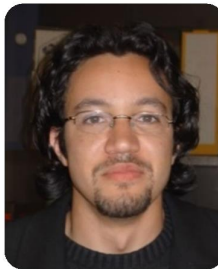
***Dr. Souad MORSLI** : Associate Professor at University of Sciences and Technology of Oran Mohamed Boudiaf / USTOMB/UL. Department of Marine Engineering.*



*Dr. Karim RAGUI : Associate Professor at Houari Boumediene University of Science and Technology (USTHB/ENS-Cachan). His research interest focuses on the thermosolutal convection phenomenon, viscoplastic materials & its rheological behavior, SiC porous matrix, pollutants spreading, energy optimizations, modeling and numerical simulation. He is a reviewer of some Elsevier & Springer journals, such Int.J. of Heat and Mass Transfer & Journal of Statistical Physics.*



*Dr. Ikram EL ABBASSI : Associate Professor at ECAM-EPMI. Head Director of Strategic Development in ECAM-EMPI.*



*Dr. Mahdi TEKITEK : Associate Professor at Faculty of science of Tunis. Member of Tunisian Society of Mathematics.*

*Warm thanks to the reviewers, the administration staff, and the students, as well, for their devotion, allowing the organization success of the present event.*

# KEYNOTE/INVITED LECTURER



**Prof. Biagio Morrone:** biomass energy conversion University of Campania, Italy.

**Subject:** *The use of residual biomass resources for recovering energy and matter.*

Biomass is a complex mix made up of various natural constituents, which can be originated from algae, plant, animal and municipal residues as well as agricultural, agro-food residues derived by industrial processing and food waste. Their different chemical and physical compositions require distinct processes to obtain either directly energy or bio-fuels and biomaterials. The thermochemical, biochemical or physical-chemical conversion pathways are the possible roads to produce energy. Thermochemical process include pyrolysis and gasification. In these cases, the resulting products can vary strictly depending on process parameters. Biochemical methods include the anaerobic digestion, which is quite an efficient way of producing biogas. The main process parameters, which affect the biogas production are pH of the substrate, temperature, partial pressure of biogas. Results displayed herein show that buffalo manure fermentation can produce biogas with a methane concentration around 65% with interesting yields. Pre-treating the substrate and changing temperature and pH of process allow to extract hydrogen up to a 15% of concentration from the same substrate.

Not only energy but also matter can be recovered from organic waste. In fact, lactic acid extraction using anaerobic fermentation can be obtained considering tomato waste residues from agro-food industry. Different results are obtained using different bacterial consortia or mixtures of them. The highlighted results show the dramatic potential of residual biomasses, which represent a giant step to the future for recovering both energy and matter and tackling with climate change as well as land and ecosystem degradation, simultaneously addressing the growing demand for food, feed, energy, materials and products due to an increasing world population, and reducing dependence on fossil fuel energy resources.

**Biography:** Prof. Biagio Morrone received his Master Degree in Mechanical Engineering in 1992, University of Naples Federico II, earned his Ph.D. in 1995, University of Naples Federico II, defending a thesis on numerical and experimental natural convection in channels; 1994, Visiting Ph.D. student at Idaho State University, USA, on numerical analysis of the electronic components cooling and analytical solutions of heat transfer in solid; 1998-2002 junior researcher and 2002-today associate professor of Applied Thermodynamics and Energy Management at University of Campania; member of the College of Doctorate in "Maths, Physics and Engineering applications" teaching courses on Numerical Methods in Physics and Engineering; leading researcher of scientific projects aimed to produce bio-hydrogen and

bio-methane from animal manure and organic fraction of municipal solid waste; leading researcher of a scientific project on Ground Energy Pile Heat Pumps; Invited speaker at several conferences on the use of bio-hydrogen in Internal Combustion Engines; co-author of about 50 scientific publications on international journals, many others presented at international and national conferences and several book chapters; his main research interests are: biomass energy conversion, alternative fuels for internal combustion engines, ground coupled heat pumps, numerical heat transfer.



**Prof. Chiheb BOUDEN:** National School of Engineers of Tunis (ENIT), Tunisia.

**Subject: Tunisia Energy Outlook: A prospective presentation at the horizon 2030.**

Tunisia Fossil fuel production is in recession. The country became a net importer since 2000. The energy deficit of the country is increasing every year. 97% of the electricity production is relying on Gas which is half produced locally and half imported from Algeria while only 3% comes from renewables (mainly wind). Due to economic and social reasons, the electricity is largely subsidized. The total energy subsidy is a heavy burden on the country budget. The energy demand is supposed to be multiplied by 02 in 2030; this will have serious consequences on the country budget and will influence the trade balance. A solar plan has been established, it aims to provide 30% of the electricity needs from renewables at the horizon 2030. This measure has to be accompanied by the introduction of a large scale storage system and a reliable grid interconnection. In parallel a large energy conservation program has to be consolidated and carefully implemented. The selection of the technologies has to be chosen according to technical and economic criteria. Social aspects have to be also considered this includes job creation, technology integration, regional development ...etc.

The Electricity system in Tunisia has been modelled using the open source code OSeMOSYS. Different Scenarios for the integration of Renewable Energy in the electricity production system have been investigated. The model took in consideration economic, technical and social aspects. Through our Keynote, a presentation of the energy situation in Tunisia will be given, as well as an outlook of the solar plan at the horizon 2030. The OSeMOSYS simulation results including future insights will be presented. It includes: (I) government inquiries (evolution of the demand, the needed installed capacity, the technologies, ...), (II) economic impacts such as the evolution of the price, the impact on the trade balance and on the budget, (III) social considerations such as technology integration, development of the industry, job creation ...etc.

**Biography:** Chiheb BOUDEN is professor at the National School of Engineers of Tunis (ENIT) where he was successively research engineer, associate Professor and then full

*Professor in fields pertaining to renewable energy, modelling and simulation of energy systems, instrumentation for engineers and energy conservation in buildings. Chiheb BOUDEN graduated in 1984 with a civil engineering diploma from Ecole Nationale d'Ingénieurs de Tunis (ENIT), a Diplôme d'Etudes Approfondies in Solar Energy from Paris-Diderot University in 1985 and a (Doctorat) in Physics and Energy from the same university in 1989. He has directed a wide range of research projects supported by the Tunisian Ministry in charge of Scientific Research, the Tunisian Energy Agency in Tunisia as well as industry. He also contributed to many international collaborative research projects including universities from France, Spain, U.K. and Greece and coordinated the Tunisian groups for at least 4 European funded research projects (FP6 and FP7). He authored and co-authored numerous scientific publications in these areas. He has been repeatedly visiting professor and research fellow at several universities in Europe and in the United States of America. Prof. BOUDEN is very active in the community work and in civil society; he is fellow of many scientific societies and took many responsibilities in National and International Associations. At the level of higher education management, he held the position of Head of the Industrial Engineering Department of ENIT then Director General of the National School of Engineers of Tunis (ENIT) from 2008 to 2014. In 2014, he was nominated as Director General of Higher Education in the Ministry of Higher Education and Scientific Research. He was appointed as Minister of Higher Education and Scientific Research from February 2015 to August 2016.*



**Pr. Amina MATAOUI:** *University of Sciences and Technology H. Boumediene, Algeria.*

**Subject:** *Turbulence modeling of impinging turbulent jets on flow and heat transfer characteristics.*

*Since more than half a century, impinging jet heat transfer has been investigated in many studies. They can be easily introduced into industrial devices and often generate local improvements in heat and mass transfer. Numerical methods based on the Reynolds Averaged Navier–Stokes (RANS) and Large Eddy Simulation (LES) equations are applied to the thermal prediction of flows of different impinging jets. Several types of jets interactions are considered.*

**Biography:** *Amina Mataoui has been a Professor of Physics in Theoretical and Applied Laboratory of Fluid Mechanics, University of Science and Technology Houari Boumediene–USTHB, Algiers. She has been active in turbulence research for three decades. My research concerns the development of numerical methods for the prediction of unsteady fluid flows. My main areas of interest are flows about jets and flow control of heated turbulent flow.*





**Prof. Sadik Dost:** Dip. Eng., Ph.D. Department of Mechanical Engineering, Crystal Growth Laboratory, University of Victoria, Victoria, BC, Canada.

**Subject: Growth of Semiconductor Single Crystals for Energy Conversion.**

Single crystal and polycrystalline semiconducting materials of silicon (Si), germanium (Ge), cadmium zinc telluride (CdZnTe) and gallium antimonide (GaSb) have been used for energy conversion in the visible and infrared spectrum. The talk will present an overview of single crystal growth of GaSb, CdZnTe and Silicon-Germanium (SiGe) from metallic solutions and melt. The growth techniques used at the University of Victoria are the solution growth techniques of the Travelling Heater Method (THM) for GaSb and CdTe, Liquid Phase Diffusion (LPD) for SiGe, and the melt growth method of Vertical Gradient Freezing (VGF) for CdZnTe. The progress and the remaining issues of these growth processes will be discussed. Recent Experimental and numerical simulation results will be presented.

**Biography:** Dr. Dost is Professor and Director of the Crystal Growth Laboratory at the University of Victoria since 1989. He graduated from Karadeniz Technical University of Turkey in 1969 and obtained his Ph.D. in Istanbul Technical University in 1974. He has then worked as a faculty member in Ege University of Turkey until 1980 and then in the University of Calgary until 1989. He is the founding director of a university research centre: CAMTEC (Centre for advanced materials and related technology) at UVic, and served as its Director from 1992 to 1997. He has also served as Chair of the Department of Mechanical Engineering at UVic from 1997 to 2003. Dr. Dost has been a Canada Research Chair in Crystal Growth from 2003 to 2017. His research combines experimental and theoretical study of growth of bulk single crystals from melt and solution using a variety of crystal growth processes such as Bridgman (B), Vertical Gradient Freezing (VGF), Liquid Phase Electroepitaxy (LPEE), Liquid Phase Epitaxy (LPE), Travelling Heater Method (THM), Liquid Phase Diffusion (LPD), Float-Zone (FZ), and Top-Seeded Solution Growth (TSSG). He has made significant contributions to these techniques.



**Dr. Hélène AGEORGES:** Limoges University, IRCER, France.

**Subject: Thermal spraying: A solution for the development of new material coatings with high performances.**

Society evolution towards increasingly efficient technologies, high speeds and yields, at low energy costs and with increased environmental and safety requirements, has found solutions in the development of new materials and their shaping such as surface coatings to improve the use

properties and hence performance of parts in service. In the aeronautics sector, for example, the development of thermal barriers to protect metal parts from gas turbine engines (combustion chamber, blades, etc.) has increased the operating temperature and power of turbojets. In addition, in different applications, because wear is one of the main causes of the destruction of materials and losses of equipment mechanical performances, the improvement of surface properties by surface treatment with coatings having high performance against abrasive, corrosive and erosive wear at room or/and extreme conditions of temperature, oxidation and pressure, has led to important savings of materials, an increase of the reliability and the longevity of equipments, and also contribute to the environmental protection, reducing energy consumption by increasing the periods of renewal of the integrated components. Since these last decades, thermal spraying with high thermal and kinetic energy processes, has increasingly been used in industry for developing surface coverings of parts subject to extreme conditions and a lot of studies are dedicated to the improvement of coatings. Nanostructured coatings are more and more considered in scientific literature because of their positive contributions to improving coating properties such as toughness, wear resistance or thermal properties.

**Biography:** Dr. Hélène Ageorges is an Associate Professor of Renewable Energy and Thermal Spraying at the University of Limoges. Head of Bachelor Program of Renewable Energy. Head of the Master Program of Energy Efficiency and Sustainable Development (Dual Diploma University of Limoges / University of Mascareignes in Mauritius. Researcher in Surface Engineering by Thermal Spray Technologies at the Institute of research for ceramics, France. Her research topics focus on advanced properties of coatings through the use of new materials and innovative processes in fields such as high wear resistance, low friction coefficient, high temperature protective coatings (thermal and environmental barrier coatings), bioactivity (implant coatings), photocatalysis to meet the requirements of various specific applications. She studies nano and micro-structure coating effects, tribology, wear mechanisms. She contributes to the development of new easy and quick methods of mechanical property measurements for industry. Dr. Ageorges also had contributions to the manufacturing of feedstock powders for thermal spray coatings: cermets, composites and bioactive glasses for biomedical use. She holds a PhD in plasma process engineering from the University of Toulouse, France.



**Pr. Ali ZAOUÏ**, LGCGE Department, Lille-1 University, France.

**Subject: New developments in civil engineering materials: water and environment effects.**

In this talk I will present some recent theoretical results based on Molecular dynamics and Monte Carlo simulations related to hydrated clay systems. The focus will be on the swelling and shrinking phenomena

on the clays under temperature and pressure effects. I will show that the hysteresis noticed in the swelling and shrinking processes is due to the different mechanisms of adsorption and desorption by breaking and re-formation of hydrogen bonds between the water molecules. Moreover I will discuss the case of the presence of cations such as some heavy metals. Besides, I will show the adsorption of water nano-droplet on the surface of the clay and discuss the effect of high pressure on the clay leading to a more rigid system. This could be a new way to create, from simple clay, harder materials for a number of uses. In addition, I will also present some recent studies regarding the interaction between calcite and clay as well as calcite and concrete. The studies take into account the role of water in both cases. I will show, additionally, the possibility of enhancing the mechanical properties of cementitious materials by incorporating some nano-materials such as carbon nanotube. Finally I will discuss the environmental aspects mainly related to the radio-nucleides and clays, and the sequestration of CO<sub>2</sub>.

**Biography:** Prof. Ali Zaoui is a full Professor of Universities (Polytech'Lille / University of Lille1) since February 2005. He is actually a Distinguish Professor (Professor of Exceptional Class 2). He got his PhD from the University of Metz. He was employed as a research associate at the INFN (National Institute of Matter Physics), Italy. He then jointed the Max Planck Institute of Stuttgart, in Germany. His research was mainly dedicated to the modeling and simulation methods based on first-principles, molecular dynamics and Monte Carlo. They cover a wide range of civil engineering materials including geo-materials (rocks, clays,...), water, interaction water and soil, environment, nano-composites. He has published over 180 papers in international journals and has supervised more than 20 PhD students.



**Pr. Mimoun EL-MARSSI :** Picardy Jules-Verne University, Amiens, France.

**Subject: Ferroic superlattice materials: Strain effects and physical properties.**

Perovskites are known to be very sensitive to even small distortion and their properties can be modified by mechanical constraints within the superlattice (SL). The lattice strain variations within the constituent layers of the artificial SL may change profoundly properties of each layer.

Stress effects govern physical properties of thin films and SLs and better understanding of these factors is obviously required to achieve reliability of ferroic properties desirable for device engineering. Here, we show how the physical properties are changed compared to those known in bulk materials or in conventional single films depending on modulation period and layer thickness of alternating compounds.

**Biography:** Mimoun El Marssi is Professor at University of Picardy, Amiens in France. He is the head of the laboratory of Physics of Condensed Matter (LPMC). He conducts research

on the synthesis and characterization of ferroic materials with controlled structures and functionalities for electronic and energy. A large part of his research concerns the use of Raman spectroscopy to study the symmetries, stresses and phase transitions in ferroic materials bulk, epitaxial thin films and superlattices. Recently, he interested to study the lead-free electrocaloric materials.



**Pr. Abdelilah BENYOUSSE:** Hassan II Academy of Science & Technology, Mohammed V University, Materials & Nanomaterials Center (MAScIR), Morocco.

**Subject:** *Properties of some two-dimensional Materials by Density Functional Theory : Application for energy conversion and storage.*

Density functional theory (DFT) is one of the most effective and widely used simulation methods in the field of materials. It is a quantum mechanical approach, which does not use experimentally derived parameters. The crystal structure of the material is the only input into these DFT calculations, but even this structure can also be calculated by the DFT. Currently, Density functional theory, helped to make huge advances in the design of emerging materials and nanomaterials for energy conversion and storage. The discovery of 2D materials has generated a new era of materials science with applications in energy and spintronics. New thin materials, stable mechanically, thermally and electronically, are available and used for the fabrication of ultrathin flexible devices. The understanding of the properties of, 2D materials, is based on the electronic properties. Density Functional theory is a Powerful Quantum mechanics method for the design of 2D Materials. Recently, phosphorene, a two dimensional phosphorus analogue of graphene, has been discovered. It is suitable as a metal-free water splitting photocatalyst. In addition, it is a promising anode material for (Li/Na/Mg)-ion batteries. The solid-state hydrogen storage is based on the interaction between the hydrogen and the surface of the storage material. The storage capabilities of nanostructured materials is high due to their enormous surface area. 2D Phosphorene is a promising material for solid-state hydrogen storage.

**Biography:** Prof. Abdelilah BENYOUSSEF received his (Doctorat d'état) degree from the Paris-Sud University in 1983. He is a permanent member of the Moroccan Hassan II Academy of Science and Technology, since 2006. He is associate professor in the materials and nanomaterials center of the Moroccan Foundation for Advanced Science, Innovation and Research. He is National coordinator of the Competences Pole of Condensed Matter and Systems Modeling. He is also an editor in chief of the Moroccan Journal of Condensed Matter. He is President of the Moroccan Society of Statistical Physics and Condensed Matter. He has been visiting professor in many research centers, laboratories and Universities. The main interest topics of Abdelilah Benyoussef are Ab initio calculation and Monte carlo

method in modeling and simulation of new materials for renewable energy; Magnetism and phase transition in condensed matter; complex systems and critical self-organization in statistical physics. He is a co-author of more than 400 research publications and book chapters and about 100 conference presentations including numerous invited papers and talks. He has co-chaired or co-organized several international conferences. He holds a number of patents and supervised 40 postgraduate research candidates.



**Dr. Yamina Lahmar MEBDOUA:** CDTA, Algeria.

**Subject:** *Surface treatment for Energy Applications.*

**Biography:** *Dr. Yamina Mebdoua est maître de recherche et chef d'équipe de projection thermique au centre de développement des technologies (CDTA) à Alger. Elle est titulaire d'un doctorat en procédés céramiques et traitement de surfaces de la faculté des sciences et techniques de l'université de Limoges en 2008, d'un magister d'astrophysique de l'université de Blida (Algérie) et d'un diplôme d'études supérieures (DES) de physique-rayonnements de l'USTHB (Alger).*

# SYMPOSIUM TALKS

**Subject: Exergo-economics: the melting pot of thermodynamic and economic concerns.**



*Exergy is a comprehensive concept that includes the first and second principles of thermodynamics and represents the best way to treat complex thermal systems that involve different types of energy flows (thermal, electrical, mechanical, and chemical, etc.). Therefore, any search for energy efficiency or optimization of a system must use exergy. At the same time, the engineer should minimize the operating and capital costs of the system. The Exergo-Economy approach is a combination of economic and economic analysis and its results allow to answer to these engineering concerns.*

**Dr Abdelhamid Kheiri:** is a member of LEMTA laboratory (Lorraine University and CNRS), France. He is a Thermodynamic and Thermal systems specialist and its current researches include System Energy Integration where the optimizations seek energy and exergy efficiencies as well as overall cost reduction.

**Subject: Photonics for Energy.**

*Research on the applications of photonics for renewable energy is at the forefront of actual discoveries and innovation. All the light spectrum is concerned, from the UV down to the micro-wave range. Research encompasses light harvesting, conversion, storage, distribution, monitoring, consumption, and its efficient use.*



**Dr. Hassina Derbal Habak:** obtained her graduated on "Capteurs Optiques et Instrumentations from University of Angers and made her PhD thesis in same University in the same Laboratory PHIA. She worked on elaboration and characterization of structured organic solar cells. She demonstrated the relation between morphology, physico-chemical and electrical characteristics of the cells. She studied and used new materials as C60 derivatives and Carbon Nanotubes for improving solar cells' performance. She Joined for her Post-Doc IM2NP and LPCIM-Ecole Polytechnique. She studied new solar cells based on CNT or Silicon amorphous as electrodes. She had interest into interface effects on IV parameters and optical characteristics. She is Full Professor associate in University of Picardie Jules Verne-France from Laboratoire de Technologie Innovante LTI.



**Prof. Jean-Michel Nunzi:** graduated from l'Ecole de Physique et Chime, Paris in 1982, he joined l'Ecole Polytechnique for a PhD on the nonlinear optics of surface plasma waves (plasmons). He was then hired as full-time Researcher in Organic Photonics at the Atomic Energy Commission (Saclay) in 1984. He joined the Department of Physics at the University of Angers as Professor in 2000, where he built the Plastic Solar Cells Technology Research Team. He moved to Queen's University as Tier 1 Canada Research Chair in Chiral Photonics in 2006, renamed Photonics for Life in 2013. He studies Organic Photonics, including the Chemistry, Processing and Physics of nanomaterials and devices. His Google H-factor is 52.

**Subject: Refrigeration, Cooling and Air Conditioning.**

The symposium Refrigeration, Cooling and Air Conditioning Conference covers a wide range of topics of interest to researchers and engineers involved in the development of technology improvements and/or assessments of cooling, air conditioning and refrigeration equipment. The topics ranging from fundamental to applied, including modeling of components and systems, heat exchanger enhancements and characterizations, domestic, commercial and industrial refrigeration, heat pumps, cooling, refrigeration and air conditioning using any form energy : renewable energy, geothermal.



**Pr. Slimane GABSI:** of National School of Engineers (Sfax), Doctorat d'Etat PHYSICAL SCIENCES Mention "Process Engineering Dec. 3, 1987" Thermodynamics of irreversible processes applied to process engineering: Simulation of unit operations in dynamic mode fluctuation (National Polytechnic Institute of Toulouse, National School of Chemical Engineering Engineers TOULOUSE). Professor of Chemical Engineering and Process at the National School of Engineers of GABES and Sfax, Director of the Higher Institute of Technological Studies of Sfax (1999-2006), Director of the Higher Institute of Biotechnology of

Sfax (2006 -2011). Research Axes a) solar refrigeration by absorption and adsorption, b) solar desalination with the technique solar pond coupled with a heat pump, the humidification-dehumidification technique, the technique of membrane distillation, c) cooling technologies, 09 Research projects in the field of chemical engineering and automation. 03 Federating research projects PRF energy air conditioning with natural gas, solar refrigeration, water heating, 02 European project on solar membranes desalination, international cooperation projects France, CNRS, Spain, Morocco, Syria. Director of twenty PhD and Master and 10 PhD in progress. 02 Patents, Authors and co-author of more than 300 publications.



**Pr. Abdallah MHIMID:** of National School of Engineers (Monastir), Tunisia. Doctorate of PHYSICAL SCIENCES specialty "energetic" obtained in July 1991 and University Habilitation in physics untitled "heat and mass transfers in porous media" in 2001 at the faculty of science of Tunis. Professor of Energetic Engineering at the National School of Engineers of Monastir, Director of ENIM's Department of Energetic Engineering (2005-2008), and Director of the Graduate School of Engineering Sciences and Technology (since 2014). Research topics a) Adsorption solar refrigeration, b) heat and mass transfer in porous media: application to drying and adsorption phenomena c) combustion. Member of an International cooperation project in France, CNRS (Rouen) on the combustion of olive cake and a National project on the characterization of insulating bricks. Director of 21 masters, 10 doctorates and 06 doctorates in progress. Authors and co-author of more than 45 articles in international journals and 70 papers.

**Subject: New cementitious materials of the building.**

New cementitious materials of building team is pleased to welcome all experts in the field of civil engineering, to attend its symposium, which will be held April 23 In 26, this event showcases innovative project and research performed about cementitious, bio-sourced and eco-materials, including their effects on environment and different type of concrete as well eco-friendly and heavyweight concrete, to finally conclude their mechanical, chemical and thermal properties.



**Pr. El-Hadj KADRI,** University of Cergy Pontoise, France University Degrees 2009 Habilitation to Direct Researches, University Cergy 1998 PhD Civil Engineering, Cergy-Pontoise University 1994 DEA Civil Engineering, INSA Lyon 1984 Engineer, ENTP, Algiers Responsibilities 2011-Present Full Professor, University Cergy-Pontoise 2012-Present Head of second year of Intelligent Building Master 2015-Present Assistant Director of L2MGC Laboratory, Cergy-Pontoise University Research Activities - Study of rheological behavior of cementitious materials depending on the used processing technique (adhesion, rendering, pumping, injection...) - Development of advanced materials for sustainable construction (by-product, recycled materials, repair mortars, bio-composite (date palm) , adhesives tile, fibre...) - Publications International Journa

**Subject: Modeling and simulation of heat transfer during solid-liquid phase change.**

Phase change materials (PCMs) are substances that store and release relatively high thermal energy in latent form during the processes of melting and solidification. They can be used in a large variety of practical applications such as thermal energy storage, air conditioning and



heating, electronic cooling, cold storage, ingot solidification and scrap melting in metallurgy. The melting and solidification processes which occur during the phase change of PCM are classified "free boundary problem" or "moving boundary problem".

Due to the presence of the moving solid-liquid interface, phase change problems are complex to solve. Indeed, the determination of the position of this moving boundary is an important part of the solution procedure. The mathematician Stefan gives the first detailed study of this type of problems and treats the formation of ice in the polar seas. Since this work, many other researchers, create, develop and apply mathematical models and computational methods to melting and freezing problems. The symposium on PCMs and their applications is an opportunity to promote the interaction between researchers involved in the development and application of approaches to treat the solid-liquid phase change processes occurring in PCMs.



**Dr. Hamid El QARNIA:** Doctorat in Energetic (November 1988) from Cadi Ayyad University (Marrakesh, Morocco) and his PhD in Mechanical Engineering on the topic of PCM integrated in heat exchangers to prevent frosting (June 1999) from Sherbrooke University (Québec, Canada). He has worked as Associate Professor at Faculty of sciences Semlalia (Cadi Ayyad University, Marrakesh) from 1989 to 1995. He has also worked as Assistant teacher at Mechanical Engineering Department (Sherbrooke University, Canada) from 1996 to 1999. From February to July 2000, he worked as a Postdoctoral researcher at Mechanical Engineering Department (Sherbrooke University). From February to July 2001, he worked as a consultant and supervisor of projects on heat transfer applications at ENERSTAT Entreprise at Sherbrooke (Québec, Canada). Dr. Hamid El Qarnia is currently Professor at Faculty of sciences Semlalia (Cadi Ayyad University, Marrakesh, Morocco). His actual research activities concern the modeling and simulation of heat transfer during solid-liquid phase change process to improve the design of latent heat storage systems and optimize their performances. He is also working on the application of PCM for thermal solar energy storage. He is also interested on the development of analytical solutions of solid-liquid phase change process. He has published several research papers in various international journals and conferences. He served as an editorial board for 4 journals and as a reviewer for several international journals, research project and chapter book. Further, he was member of several scientific committees of International Conferences. He was a chairman of the International Meeting on Heat Transfer (JITH2013, November 13-15, Marrakesh, Morocco). He has also organized the first Symposium on Analytical and Numerical Solutions of Melting and Solidification Problems'', SANSMSMSP 2012 (ICNAAM 2012, September 19-25, Kos, Greece).

**Subject: Heat and Mass Transfers: a perpetual challenge on Energy and Materials loop.**



**Prof. Habib SAMMOUDA:** Pr. Habib Sammouda is a full Professor at Sousse University, and Higher School of Sciences and Technology of Hammam Sousse (ESSTHS), Tunisia. Director of Energy and Materials Laboratory (LabEM) LR11ES34, and Former Director of the Higher Institute of Technological Studies of Sousse. President of the Committee of the Master Research in Physics at the ESSTHSousse in Sousse University (2011-2014), and President of the PhD committee in Engineering Physics at the ESSTHSousse, in Sousse University (2015). His research area could be summarized, between Experimental and Numerical ones, as follows: Transfer Phenomena at high temperature in solar rotary kiln filled with porous medium, Reflected Radiance distribution law for a 1000KW thermal solar furnace system, Numerical models based on finite elements method in two and three dimensions (Fortran programs), Heat and mass transfer in open cavity (rotary kiln) partially filled with porous media and subject to concentrated solar radiation, Thermosolutal convection in porous media: application to pollution, Heat transfer in porous media and composite materials, Coolants heat exchanger associated to solar photovoltaic cells sensor (PVT, CPVT), Analyse of Wood Plastic Composites (WPC), Smart Buildings , Smart Materials, PCM materials (CPVT/MCP). Recently its interest is focused on the characterization and the exploration of the correlation existing between the energy and the material along its elaboration or its adhesion to the storage operation, particularly in phase change materials and this, at two scales level. He continues to contribute for the amelioration of the convergence and the stability of Finite Element method in CFD simulations with complex fluids. The amelioration of efficiency of PV sensor PV, by proposition of exchange system PVT, and a new materials cell exposed to concentrated solar radiation CPVT in the aim to the manufacturing of domestic CPVT sensor. He contributed to supervise more than 50 master's Thesis, 30 PHD's Thesis, and authors of more than 50 publications in impacted journals. He is as reviewer in some specifically journals as: Porous Media, solar energy, Energy conversion and Management.

CONFERENCE PROGRAM

<b>Monday</b> April 22 <sup>nd</sup>	<b>Topical School 'Courses Part I' : 14:30 to 17:00</b>														
<b>Tuesday</b> April 23 <sup>rd</sup>	<b>Topical School ' Courses-Practice Part II'</b> 09:30 to 16:30							<b>REGISTRATION: 15:00 to 18:00</b> (Hotel Golden Tulip Taj Sultan Resort)							
	8:20	9:00	9:30	10:20	11:00	11:10	11:50	12:30	14:00	14:50	15:40	15:50	16:30	17:10	18:00
<b>Wednesday</b> April 24 <sup>th</sup>	Registration	Opening (MR)	Key_n 2 Prof. Chiheb BOUDEN (MR) Chairman: A. El Cafsi	Key_n 6 Dr. Hélène AGEORGES (MR) Chairman: M. El Ganaoui	Coffee Break (HS)	Symposium (Session 1) (MR) Symposium (Session 2) (SR)	POSTER (HS)	Lunch	Key_n 1 Prof. Biagio MORRONE (MR) Chairman: R. Bennacer	Key_n 8 Prof. Mimoun EI-MARSSI (MR) Chairman: H. Beji	Coffee Break (HS)	Symposium (Session 3) (MR) Symposium (Session 4) (SR)	POSTER (HS)	Commissions/ Sci. / Org.	Visit Hammamet City
	<i>Presentation &amp; poster jury</i>							<i>Presentation &amp; poster jury</i>							
<b>Thursday</b> April 25 <sup>th</sup>	8:20	9:00	10:00	11:00	11:10	11:50	12:30	14:00	14:50	15:40	15:50	16:30	17:10	18:00	
	Registration	Key_n 9 Prof. Abdelilah BENYOUSSEF (MR) Chairman: A. Kheiri	Key_n 3 Dr. Y. Lahmar MEBDOUA (MR) Chairman: H. Ageorges	Coffee Break (HS)	Symposium (Session 5) (MR) Symposium (Session 6) (SR)	POSTER (HS)	Lunch	Key_n 7 Prof. Ali ZAOUI (MR) Chairman: M. Lakhdari	Key_n 4 Prof. Sadik DOST (MR) Chairman: R. Bennacer	Coffee Break (HS)	Symposium (Session 7) (MR) Symposium (Session 8) (SR)	POSTER (HS)	Commissions/ Sci. / Org.	Banquet Dinner (Awards) (19:30)	
	<i>Presentation &amp; poster jury</i>							<i>Presentation &amp; poster jury</i>							
<b>Friday</b> April 26 <sup>th</sup>	9:00	9:50	10:00	11:00	11:40	12:00									
	Key_n 5 Pr. Bachir MEZIANI (MR) Chairman: H. Sammouda	Coffee Break (HS)	Symposium (Session 9) (MR) Symposium (Session 10) (SR)	POSTER (HS)	Closing (MR)	Commissions/ Sci. / Org.									
<i>Location: Golden Tulip Taj Sultan Resort, Hammamet, Tunisia.</i>															

Key\_n: Keynote.

Symposium: invited lecturer/Symposium.

MR: Main Room (El Bey 01).

SR: Room (El Bey 02).

HS: Hall Space.

CB: Coffee Break.

Monday April 22 <sup>nd</sup>	Topical School (Courses)	14:00 to 17:00
	Topical School (Practice)	09:30 to 16:30
Tuesday April 23 <sup>rd</sup>	Registration Golden Tulip Taj Sultan Resort	16:00-19:00



<b>WEDNESDAY</b> April 24 <sup>th</sup>	08:00	<b>Registration</b>		
	09:00	<b>Opening Ceremony (MR)</b>		
	09:30	(KEY_N2) Pr. Chiheb Bouden (MR) Chairman: A. El Cafsi		
	10:10	(KEY_N6) Pr. Hélène Ageorges (MR) Chairman: M. El Ganaoui		
	11:00	<b>Coffee Break</b>		
	11:15	Session1: Systems (MR) Chairman: A.Guizani	Session2: Materials (SR) Chairman: H. Derbal Habak	
	11:30	ID 15-20-26-39-40-45-51-63-102-118-123-128-132-139-168-174-184-187	ID 17-42- 61-72-104-126-143-151-171-172-188-189-198-203-213-215-216-110-190	
	12:30	<b>POSTER Session (HS)</b>		
	14:00	ID 15-20-26-39-40-45-51-63-102-118-123-128-132-139-168-174-184-187-17-42-61-72-104-126-143-151-171-172-188-189-198-203-213-215-216-190	H. Derbal Habak A.Guizani K.Ragui	
	14:50			
	15:40	<b>Lunch</b>		
	16:00	(KEY_N1) Pr. Biagio Morrone (MR) Chairman: R. Bennacer		(KEY_N8) Pr. Mimoun EL-Marssi (MR) Chairman: H. Beji
		<b>Coffee Break</b>		
		Session3: Materials & Building (MR) Chairman: A. Mhimid	Session4: Transport (SR) Chairman: H. Ben Hamed	
17:30	ID 5-25-37-77-125-162-163-206-137-103-119-112-155-158-160-185-157-204	ID 7-8-29-43-44-64-70-71-113-180-186-194-199-202-121-124-170-107-108		
	<b>POSTER Session (HS)</b>			
	ID 5-25-37-77-125-162-163-206-137-103-119-112-155-158-160-185- 7-8-29-43-44-64-70-71-113-180-186-194-199-202-121-124-170-107-108-204	A. Mhimid H. Ben Hamed A.Boutra		
	<b>Commissions/ sci. / Org.</b>			
	<b>Visit Hammamet City</b>			



**THURSDAY**  
 April 25<sup>th</sup>

08:00	Registration						
09:00	(KEY_N9) Pr. Abdelilah Benyoussef (MR) Chairman: A. Kheiri						
09:50	(KEY_N3) Pr. Y. Lahmar Mebdoua (MR) Chairman: H. Ageorges						
10:40	Coffee Break						
11:00	Session 5: Simulation(MR) Chairman: A. Merabtine		Session 6: Reactive flow (SR) Chairman: S. Morsli				
11:40	ID	6-10-22-23-30-32-34-35-66-67-76-130-140-178-193-205-12-14	ID	11-21-27-38-46-47-48-54-57-59-62-110-146-109-131-156,76,125,136,137,			
12:30	POSTER Session (HS)						
14:00	ID	6-10-14-22-23-30-32-34-35-66-67-76-130-140-178-193-205-11-21-27-38-46-47-48-54-57-59-62-110-146-109-131-156	<table border="1"> <tr><td>A. Merabtine</td></tr> <tr><td>S. Morsli</td></tr> <tr><td>K. Ragui</td></tr> </table>		A. Merabtine	S. Morsli	K. Ragui
A. Merabtine							
S. Morsli							
K. Ragui							
14:50	Lunch						
15:40	(KEY_N7) Pr. Ali Zaoui (MR) Chairman : M. Lakhdari						
16:00	(KEY_N4) Pr. Sadik Dost (MR) Chairman: R. Bennacer						
	Coffee Break						
	Session 7:Materials (MR) Chairman: E. Kadri		Session 8: Materials & Building /Exergie (SR) Chairman: A. Kheiri				
17:00	ID	4-13-16-19-24-33-41-69-101-145-147-115-116-117-173-197-111-133-2208	ID	10-18-49-50-56-66-74-75-179-106-142-153-212-150-183-190			
19:30	POSTER Session (HS)						
	ID	4-13-16-19-24-33-41-69-101-145-147-115-116-117-173-197-111-133-10--18-49-50-56-66-74-75-179-106-142-153-212-150-183-190	<table border="1"> <tr><td>A. Kheiri</td></tr> <tr><td>E. Kadri</td></tr> <tr><td>A. Boutra</td></tr> </table>		A. Kheiri	E. Kadri	A. Boutra
A. Kheiri							
E. Kadri							
A. Boutra							
	Commissions/ sci. / Org.						
	Banquet dinner Awards						



**International Conference on Materials and Energy  
 ICOME' 19, Hammamet-Tunisia, April 23-26, 2019**



<b>FRIDAY April 26<sup>th</sup></b>	09:00	<b>(KEY_N5) Pr. Bachir Meziani (MR) Chairman: H. Sammouda</b>				
	09:50	<b>Session 9: Transport (MR) Chairman: H. Sammouda</b>		<b>Session 10: System &amp; Reactive Flow (SR) Chairman: M. Tekitek</b>		
	10:30	<b>ID</b>	9-28-31-36-52-53-55-58-60-65-73- 176-122-141-169-105-196-	<b>ID</b>	114-127-128-144-154-161-164-165-175- 181-191-200-201-207-211	
	11:00	<b>POSTER Session (HS)</b>				
	11:20	<b>ID</b>	9-28-31-36-52-53-55-58-60-65-73-176-122-141-169-105-196-114-127-128- 144-154-161-164-165-175-181-191-200-201-207-211	<table border="1" style="margin-left: auto; margin-right: auto;"> <tr> <td style="padding: 2px;">H.Sammouda K.Ragui A.Boutra</td> </tr> </table>		H.Sammouda K.Ragui A.Boutra
	H.Sammouda K.Ragui A.Boutra					
	12:00	<b>Coffee Break</b>				
		<b>Closing</b>				
	<b>Commissions/ sci. / Org.</b>					



# TOPICAL SCHOOL



## MODELING AND SIMULATION APPROACHES FOR MATERIALS AND ENERGY, 22-23 APRIL , 2019. 5<sup>TH</sup> EDITION.

*Modeling and Simulation Approaches are vital topics, given current and future challenges of energy transition and sustainable development as well. Subsequently, our fifth Topical School Edition, namely "Modeling and Simulation Approaches for Materials and Energy" will focus on the relationship between energies' optimization and simulation topics. Such a specialized school will take place on April 22<sup>th</sup> & 23<sup>th</sup>, 2019, at the Golden Tulip Taj Sultan Resort of Hammamet city, Tunisia, and will present the latest scientific advances into the field.*

*The Topical School will include various lectures and seminars. These lectures will cover fundamental and applied aspects related to the transfer-phenomena modeling within complex media. Our lecturers are international experts in various areas, such numerical simulation approaches, renewable energy, building energy performance and durability of structures, to name but a few.*

*Our aim is to be an inter-disciplinary interface into material and energy fields, as well as the environmental one, by putting the emphasis on the renewable resources, materials for renewable energies, energy storage and optimization, bio-sourced materials for building, as well as social issues about energy and environment with contributions of international highlighting experts.*

*The Topical School is intended in order of priority to PhD students, Masters, Engineers in final year and researchers as well.*

# TOPICAL SCHOOL



## OUTLINE PROGRAM

*After each presentation by 15-20 minutes discussion/Cooperation*

### Monday, April 22:

14:30 – 15:00	OPENING	ICOME Chairs-
15:00 – 17:00	PHD – University Carrier – Engineering - Energy – Materials – Heat and Mass Transfer.	Pr. R. Bennacer Pr. M. El-Ganaoui Pr. E. Sediki Pr. A. Kheiri

### Tuesday, April 23:

09:00 – 12:00	Sharing experiences: *About the numerical approach and the industrial applications: 1-Difference between simulation and modeling. 2-Predicting only theoretical results ? 3-Some industrial applications. *What is Energy?	Dr. K. Ragui Dr. H. Ben Hamed
13:00 – 14:30	LUNCH	
14:30 – 17:00	Numerical part: 1. Installation of Python (numpy-matplotlib) 2. LBM Simulations 3. Introduction to schemes BGK et MRT 4. D1Q3 scheme for diffusion and acoustics 5. D2Q9 scheme for fluid dynamics 6. Boundary conditions 7. Applications	Pr.E. Sediki Dr. M. Tekitek Dr. A. Msaddek



# ICOME'19 AWARDS

## STUDENT AWARD

*The ICOMÉ event want to reward involvement, merit and professionalism of young scientist students. An award of better presentation (Phd) will be provided for each of the sessions and consist on the ICOMÉ medal and free fees for the next ICOMÉ edition.*



## AVERROES AWARD

*As always, The ICOMÉ Conference will provide its special Award (Averroes Prize) to support Postdoctoral or PhD students, who are working in Materials & Energy fields, and to honor one of research leaders of the recent year.*

*Started by Pr. El-Ganaoui & Pr. Bennacer a few years ago, such a special section of ICOMÉ conference raises every year to honor some best Oral/Poster presentations of participants whom offered a remarkable research work.*

*After a review decision through the ICOMÉ even, top presentations will be nominated and a special Gala-Diner on their honor will be prepared. Averroes (Ibn Rushd) is chosen to be the designation denotation of such even.*

***“Ignorance leads to fear, fear leads to hatred  
and hatred leads to violence. That is the  
equation”***

***(Averroes, 1126-1198)***



## AVERROES PRIZES OVER THE YEARS

*Averroes Prize 2016: Michel COMBARNOUS, French Academy of Sciences.*



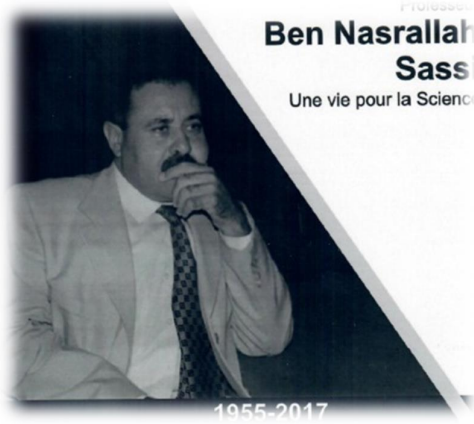
**Michel Combarnous:** Professor "Emeritus" at the University of Bordeaux, has been associate professor at the University of Gabès (Tunisia) (2006-2011). A specialist in fluid mechanics and energetics, he was encharged of the Department « Engineering Sciences » at CNRS (1980-1985). He is a founding member of « Académie des Technologies », and Corresponding Member of the Academy of Sciences, since 1978 ([www.academie-sciences.fr](http://www.academie-sciences.fr)). Pr. Combarnous has accomplished a huge cooperative work involving north-south Mediterranean cooperation.

*Averroes Prize 2017: Abdul Majeed MOHAMAD, Education Excellence awards.*



**Abdul Majeed Mohamad:** Professor in Eastern Mediterranean University, Cyprus (1993-1999). Since 2000 he is Prof. of thermofluid in Dept. of Mechanical Engineering, University of Calgary, Canada. Dr. Mohamad held few admin positions, director of graduate studies, acting director for Centre for Environmental Engineering Centre for Research and Education. Dr. Mohamad has been invited by many institutes around the world (France, Germany, China, USA, Poland, Saudi Arabia, Canada, Portugal, Morocco, Tunisia, Turkey, Indonesia, and Ecuador), as invited Professor and lecturer. He is one of the highly cited researches. Dr. Mohamad elected Fellow Member of American Society of Mechanical Engineer (ASME). Scientific council member of International Centre for Heat and Mass Transfer. He has been awarded Research Excellence and Graduate Teaching Excellence awards from University of Calgary, Dept. of Mechanical Engineering, Canada.

*Averroes Prize 2018: Sassi BEN-NASRALLAH, Presidential award in 2003.*



***Sassi Ben Nasrallah:** Born in 1955, Sassi Ben Nasrallah is a doctor in physical sciences. He joined higher education as an assistant professor at ENIS and then as a lecturer and was then promoted to the post of Professor of Higher Education at ENIM. He has contributed a lot to teaching, especially research, since in 1999 he created the Laboratory of Thermal and Energetic Systems, which is one of the most renowned laboratories both nationally and internationally. He is the author of more than 300 scientific articles in major journals, and he supervised several PhD students. Sassi Ben Nasrallah won a presidential award in 2003. The professor has also led several research projects as well as scientific meetings. He has been a professor in both Tunisian and French universities, and is well known for his studies at the Central School of Paris, IMFT Toulouse, Mine's School of Nantes and many others. Sassi Ben Nasrallah founded and chaired the Tunisian Energy Association (ATE).*

*The Ministry of Higher Education announced, on June 30 2017, the death of Sassi Ben Nasrallah, professor of higher education at the National School of Engineering of Monastir (ENIM).*

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