

ISSN 2076-2895 (Print)  
ISSN 2076-2909 (Online)

# International Journal of Energy and Environment



Volume 13, Issue 1, 10 July 2022

The Official Journal of the International Energy and Environment Foundation



# **INTERNATIONAL JOURNAL OF ENERGY AND ENVIRONMENT**

**Official Journal of the International Energy and  
Environment Foundation**

ISSN 2076-2895 (Print) ISSN 2076-2909 (Online)

**Volume 13, Issue 1, 2022**

© 2022 International Energy and Environment Foundation. All rights reserved

## Aims and Scope

The International Journal of Energy and Environment (IJEE) is the official journal of the International Energy and Environment Foundation (IEEF). The journal is a multi-disciplinary, peer-reviewed open access journal, covering all areas of energy and environment related fields that apply to the science and engineering communities. The journal enjoys the full support of the IEEF, who provide funds to cover all costs of publication, including the Article Processing Charges for all authors. Therefore the journal is both free to read and free to publish in for everyone. IJEE aims to promote rapid communication and dialogue among researchers, scientists, and engineers working in the areas of energy and environment. The journal provides a focus for activities concerning the development, assessment and management of energy and environment related programs. The emphasis is placed on original research, both analytical and experimental, which is of permanent interest to engineers and scientists, covering all aspects of energy and environment. It is hoped that this journal will prove to be an important factor in raising the standards of discussion, analyses, and evaluations relating to energy and environment programs. All articles with significant research results in the areas of energy and environment and their application are welcome.

*The scope of the journal encompasses the following:*

### Energy

- Fuel cells and their applications.
- Hydrogen energy.
- Photovoltaic technology conversion.
- Solar thermal applications.
- Wind energy.
- Hydro energy.
- Biomass and bioenergy.
- Wave and tide energy.
- Geothermal energy.
- Fuel flexibility and alternatives.
- Micro- and nano-energy systems and technologies.
- Hybrid / integrated energy systems.
- Energy conversion, conservation and management.
- Energy efficient buildings.
- Energy generation and energy storage.
- Energy modelling and prediction.
- Energy and sustainable development.
- Energy efficiency and sustainability inherent in heritage places.
- Fluid mechanics and thermodynamics, including CFD, heat transfer and combustion.
- Smart materials and structures.
- Materials for energy.

### Environment

- Energy and environmental impact.
- Thermal, acoustic, visual, air quality building science and human impacts.
- Eco-design of energy-related products.
- Green electric and electronics.
- Solutions for mitigating environmental impacts and achieving low carbon, sustainable built environments.
- Technologies and integrated systems for high performance buildings and cities.
- Tools for the design and decision-making community, including tested computational, economic, educational and policy tools.
- Environment and sustainable development.
- Quality assurance / control.
- Emissions reduction.
- Waste management.
- Evaluation & management of environmental risk and safety.
- Advanced visualization techniques, virtual environments and prototyping.
- Water-related engineering issues.

### A note to authors

#### *Submission of articles*

Submission of an article implies that the work described has not been published previously (except in the form of an abstract or as part of a published lecture or academic thesis), that it is not under consideration for publication elsewhere, that its publication is approved by all authors and tacitly or explicitly by the responsible authorities where the work was carried out, and that, if accepted, it will not be published elsewhere in the same form, in English or in any other language, including electronically without the written consent of the copyright-holder. The submitting author is responsible for obtaining agreement of all co-authors as well as any sponsors' required consent before submitting a paper. Responsibility for the content of a paper lays on the Authors and not on the Editors or the Publisher. All authors must complete the 'Journal Publishing Agreement' before the article can be published. Authors are encouraged to observe the guidelines in the preparation of their articles for submission to IJEE. Full instructions can be found on the journal homepage (<http://www.IJEE.IEEFoundation.org>).

### Your Submitted Article

- Your article will be peer-reviewed and if accepted will be published very fast.
- Your biography will appear at the end of your article.
- Your article will be published free of charge. The Authors do not pay any kind of publication fees.
- Your article will be published around the world in full color. Free use of color where this enhances the article.
- Your article can be read by potentially millions of readers, which is incomparable to publishing in a traditional subscription journal. All interested readers can read, download, and/or print your article at no cost!
- Your article will obtain more citations.
- Moreover, all articles are indexed by the major indexing media therefore providing the maximum exposure to the articles.

# INTERNATIONAL JOURNAL OF ENERGY AND ENVIRONMENT

*Official Journal of the International Energy & Environment Foundation*

*Journal homepage: [www.IJEE.IEEFoundation.org](http://www.IJEE.IEEFoundation.org)*



## **Editor-in-Chief**

**Maher A.R. Sadiq Al-Bagdadi**

*President of the International Energy and Environment Foundation (IEEF), Najaf, P.O.Box. 39, Iraq.*

## **Associate Editors**

**Hashim R. Abdol Hamid**

*Environment Research Center, International Energy and Environment Foundation (IEEF), Najaf,  
P.O.Box. 39, Iraq.*

**Muhannad Al-Waily**

*Applied Mechanics Research Center, International Energy and Environment Foundation (IEEF), Najaf,  
P.O.Box. 39, Iraq.*

## **Editorial Advisory Board**

### **Basim Ajeel Abass**

Mechanical Engineering Department, College of Engineering, Babylon University, Babylon, Iraq .

### **Ramesh K. Agarwal**

Washington University in St. Louis, 1 Brookings Drive, St. Louis, MO 63130, USA

### **Hayder Y. Ahmad**

MIMechE, CEng, 81 Suffolk Road, Harrow, HA2 7QF, UK.

### **Kadim Karim Mohsen Ali**

Materials Engineering Department, College of Engineering, University of Thi-Qar, Thi-Qar, Iraq.

### **Zaman Abud Almalik**

Mechanical Engineering Department, Faculty of Engineering, University of Kufa, Najaf, Iraq .

### **Mohsin Abdullah A. Al-Shammari**

College of Engineering, University of Baghdad, Baghdad, Iraq.

### **Amitava Bandyopadhyay**

Department of Chemical Engineering, University of Calcutta, 92, A.P.C.Road, Kolkata 700 009, India.

### **Angelo Basile**

Institute on Membrane Technology of the Italian National Research Council, ITM-CNR, c/o University of Calabria, via P. Bucci, cubo 17/C, 87030 Rende (CS), Italy.

### **Wojciech Budzianowski**

Wroclaw University of Technology, ul. Wybrzeze Wyspianskiego 27, 50-370 Wroclaw, Poland.

### **Jumaa Salman Chiad**

Prosthetic and Orthotic Engineering Department, College of Engineering, Al-Nahrain University, Baghdad, Iraq.

### **Ahmet Erklig**

University of Gaziantep, Faculty of Engineering, Mechanical Engineering Department, 27310 Gaziantep, Turkey.

### **Evangelos G. Giakoumis**

School of Mechanical Engineering, National Technical University of Athens, 9 Heroon Polytechniou St., Zografou Campus, 15780, Athens, Greece.

### **Eloy Velasco Gomez**

ETS Ingenieros Industriales, Universidad de Valladolid, Paseo del Cauce, no 59, 47011 Valladolid, Spain.

### **Abdul Kareem F. Hassan**

College of Engineering, University of Basrah, Basrah, Iraq.

### **Ahmed M. Hasson**

Mechanical Engineering Department, College of Engineering, Al-Nahrain University, Baghdad, Iraq.

### **Ihsan Y. Hussain**

College of Engineering, University of Baghdad, Baghdad, Iraq.

### **Mahmud Rasheed Ismail**

Prosthetic and Orthotic Engineering Department, College of Engineering, Al-Nahrain University, Baghdad, Iraq.

### **Muhsin Jweeg**

Telafer University, College of Engineering, Iraq.

### **Arunachala Nadar Kannan**

Department of Engineering Technology, TECH 156, Arizona State University, 7001 E Williams Field Rd, Mesa, AZ 85212, U.S.A.

### **T. Lu**

School of Mechanical and Electrical Engineering, Beisanhuan East Road, Chaoyang District, Beijing 100029, P.R.China.

**A. Mani**

Refrigeration and Air-conditioning Laboratory,  
Department of Mechanical Engineering, Indian Institute  
of Technology Madras, Chennai 36, Pincode 600 036,  
India.

**Ameen Ahmed Nassar**

College of Engineering, University of Basrah, Basrah,  
Iraq.

**Meng Ni**

Department of Building and Real Estate, The Hong Kong  
Polytechnic University, Hung Hom, Kowloon, Hong  
Kong.

**Jawad Kadhim Olewi**

Materials Engineering Department, University of  
Technology, Baghdad, Iraq.

**S-J Park**

Department of Chemistry, Inha University, 253  
Yonghyun-dong, Nam-gu 402-751, Korea (south).

**Andreas Poullikkas**

Electricity Authority of Cyprus, 1399 Nicosia, Cyprus.

**Md. Mujibur Rahman**

Department of Mechanical Engineering, College of  
Engineering, Universiti Tenaga Nasional, Km 7, Jalan  
Kajang-Puchong, 43009 Kajang, Selangor, Malaysia.

**Julien Ramousse**

Polytech'Savoie, Université de Savoie, Campus  
scientifique, Savoie Technolac, 73376 Le Bourget, du  
Lac, CEDEX, France.

**Teemu Rasanen**

Research Group of Environmental Informatics,  
Department of Environmental Sciences, University of  
Kuopio, FI-70211 Kuopio, Finland.

**Kadhim Kamil Resan**

College of Engineering, Al-mustansiriyah University,  
Baghdad, Iraq.

**Marc A. Rosen**

University of Ontario Institute of Technology, Faculty of  
Engineering and Applied Science, 2000 Simcoe Street  
North, Oshawa, Ontario, L1H 7K4, Canada.

**David Michael Rowe**

Cardiff School of Engineering, Queen's Buildings,  
Newport Road Cardiff CF24 1XF, U.K.

**Hisham M. Sabir**

Kingston University, Faculty of Engineering, Friars  
Avenue, London SW15 3DW, U.K.

**Suresh Babu Sadineni**

Center for Energy Research, Department of Mechanical  
Engineering, Howard R. Hughes College of Engineering,  
University of Nevada, Las Vegas (UNLV) 89154-4027,  
U.S.A.

**Bidyut Baran Saha**

Department of Mechanical Engineering, National  
University of Singapore, 9 Engineering Drive 1, 117576,  
Singapore.

**Vicente Salas**

Department of Electronic Technology, Universidad Carlos  
III de Madrid, Avda. de la Universidad, 30, 28911  
Leganes, Madrid, Spain.

**Amin U. Sarkar**

School of Business, Alabama A&M University, Normal  
(Huntsville), AL 35762, U.S.A.

**Moinuddin Sarker**

Natural State Research, Inc., 37 Brown House Road  
(Second Floor), Stamford, CT-06902, USA.

**Joop Schoonman**

Department DelftChemTech: Materials for Energy  
Conversion and Storage, Delft University of Technology,  
Julianalaan 136, 2628 BL Delft, The Netherlands.

**Tomonobu Senjyu**

University of the Ryukyus, Faculty of Engineering, 1  
Senbaru Nishihara-cho Nakagami Okinawa 903-0213,  
Japan.

**Jose Ramon Serrano**

Universidad Politécnica de Valencia, CMT-Motores  
Térmicos, Camino de Vera s/n, 46022 Valencia, Spain.

**Haroun A.K. Shahad**

Department of Mechanical Engineering, University of  
Babylon, Babylon, Iraq

**Rajnish N. Sharma**

Department of Mechanical Engineering, University of  
Auckland, Private Bag 92019, Auckland 1142, New  
Zealand.

**S.A. Sherif**

HVAC Laboratory, Department of Mechanical and  
Aerospace Engineering, University of Florida, 232 MAE  
Bldg. B, Gainesville, Florida 32611-6300, U.S.A.

**Shailendra Kumar Shukla**

Department of Mechanical Engineering, Institute of  
Technology, B.H.U., Varanasi-221005, India.

**Rayan Slim**

Center for Energy and Processes, Ecole des Mines de  
Paris, 104 Bobillot Street, 75013 Paris, France.

**Laizhou Song**

Department of Environmental and Chemical Engineering,  
Yanshan University, Qinhuangdao City, Hebei Province,  
P.R.China.

**Adnan Sozen**

Department of Mechanical Education, Gazi University,  
Technical Education Faculty 06500 Teknikokullar,  
Ankara Turkey.

**Roland Span**

Lehrstuhl für Thermodynamik, Ruhr-University Bochum,  
D-44780 Bochum, Germany.

**Anurag K. Srivastava**

Electrical and Computer Engineering, Mississippi State  
University, 216 Simrall Hall, Hardy Road, Mississippi  
State, MS 39762, U.S.A.

**Rosetta Steeneveldt**

Research Centre Trondheim, StatoilHydro, Arkitekt  
Ebbells vei 10, N 7005 Trondheim, Norway.

**Athina Stegou-Sagia**

School of Mechanical Engineering, Department of  
Thermal Engineering, National Technical University of  
Athens, 9 Iroon Polytechniou Str. Zografou 157 80,  
Athens, Greece.

**Peter Stigson**

School of Sustainable Development of Society and Technology, Mälardalen University, 721 23 Västerås, Sweden.

**Anna Stoppato**

Department of Mechanical Engineering, University of Padova, via Venezia, 1-35131 Padova, Italy.

**Michael Stoukides**

Department of Chemical Engineering, Aristotle University of Thessaloniki, Thessaloniki 54124, Greece.

**Jian-Feng Sun**

College of Food Science and Technology, Agricultural University of Hebei, Baoding City, Hebei Province, 071000 P.R.China.

**Stanislaw Szwaja**

Department of Engineering Mechanics, Michigan Technological University, 1400 Townsend Drive, Houghton, MI, 49931, U.S.A.

**Ayad Murad Takak**

Mechanical Engineering Department, College of Engineering, Al-Nahrain University, Baghdad, Iraq.

**David S-K. Ting**

Mechanical, Automotive & Materials Engineering, University of Windsor, Windsor, Ontario, N9B 3P4, Canada.

**G. N. Tiwari**

Centre for Energy Studies, Indian Institute of Technology Delhi, Hauz Khas, New Delhi - 110 016, India.

**Bor-Jang Tsai**

Department of Mechanical Engineering, Chung Hua University, No. 707, Sec. 2, Wu Fu Rd., Hsinchu 300, Taiwan.

**Athanasios Tsolakis**

School of Mechanical Engineering, University of Birmingham, Edgbaston, Birmingham, B15 2TT, U.K.

**Per Tunestal**

Department of Energy Sciences, Lund University, SE-221 00 Lund, Sweden.

**Aynur Ucar**

Department of Mechanical Engineering, Firat University, Elazig, Turkey.

**Despina Vamvuka**

Department of Mineral Resources Engineering, Technical University of Crete, University Campus, Hania 73100, Crete, Greece.

**Virendra Kumar Vijay**

Centre for Rural Development and Technology, Indian Institute of Technology Delhi, Hauz Khas, New Delhi 110016, India.

**Roberto Volpe**

Faculty of Engineering and Architecture, Università degli Studi di Enna "Kore" Cittadella Universitaria, 94100 - Enna, Italy.

**Shengwei Wang**

Department of Building Services Engineering, The Hong Kong Polytechnic University, Hong Kong.

**Yi-Ming Wei**

Center for Energy and Environmental Policy Research (CEEP), Beijing Institute of Technology, No.5 South Zhongguancun Street, Haidian District, Beijing 100081, P.R.China.

**Samantha Wijewardane**

Laboratory for Advanced Materials, Science and Technology (LAMSAT), Department of Physics, University of South Florida, 4202 E. Fowler Ave., Tampa, FL 33620, USA.

**Gwomei Wu**

Chang Gung University, 259 Wen Hua 1st Road, Kweisan, Taoyuan 333, Taiwan.





## Contents

<b>Combating climate change with hydrogen.</b> <i>Maheer A.R. Sadiq Al-Baghdadi</i>	1-18
<b>Electrochemical impedance spectroscopy behavior of aluminum alloys 2024 and 6061 in rainwater.</b> <i>Sahib M. Mahdi, Saraa M. Mohammed</i>	19-26
<b>An investigation of dynamic behaviour of cracked porous graded moving plate under thermal environment.</b> <i>Rusul J. Manshad, Talib EH. Elaikh</i>	27-44
<b>Optimal design of elastic curved shank of below knee prosthesis.</b> <i>Ammar M. Khalaf, Mahmud. R. Ismail</i>	45-52

### ANNOUNCEMENTS - IEEF RELEASE

- BOOK: CFD Applications in Energy and Environment Sectors: Volume 1.**  
*Editors: Maheer A.R. Sadiq Al-Baghdadi and Hashim R. Abdol Hamid (ISBN 13: 978-1-46623-065-1)*
- BOOK: Engineering Applications of Computational Fluid Dynamics: Volume 1.**  
*Editor: Maheer A.R. Sadiq Al-Baghdadi (ISBN 13: 978-1-46623-106-1)*
- BOOK: CFD Modeling in Development of Renewable Energy Applications.**  
*Editor: Maheer A.R. Sadiq Al-Baghdadi (ISBN 13: 978-1-46623-131-3)*
- BOOK: Engineering Applications of Computational Fluid Dynamics: Volume 2.**  
*Editor: Maheer A.R. Sadiq Al-Baghdadi (ISBN 13: 978-1-47832-935-0)*
- BOOK: PEM Fuel Cells - Fundamentals, Modeling, and Applications.**  
*Author: Maheer A.R. Sadiq Al-Baghdadi (ISBN 13: 978-1-48197-823-1)*
- BOOK: Alternative Fuels Research Progress.**  
*Editor: Maheer A.R. Sadiq Al-Baghdadi (ISBN 13: 978-1-48405-771-1)*
- BOOK: Computational Fluid Dynamics Applications in Green Design.**  
*Editor: Maheer A.R. Sadiq Al-Baghdadi (ISBN 13: 978-1-49487-575-6)*
- BOOK: Stress Redistribution in Composite Materials.**  
*Author: Luay S. Alansari (ISBN 13: 978-1-49730-742-1)*
- BOOK: PEM Fuel Cells from Single Cell to Stack - Fundamental, Modeling, Analysis, and Applications.**  
*Author: Maheer A.R. Sadiq Al-Baghdadi (ISBN 13: 978-1-50588-564-4)*
- BOOK: Dynamic Analysis Investigation of Stiffened and Un-Stiffened Composite Laminated Plate Subjected to Transient Loading.**  
*Author: Muhannad Al-Waily (ISBN 13: 978-1-50757-536-9)*
- BOOK: Analytical and Numerical Buckling and Vibration Investigation of Isotropic and Orthotropic Hyper Composite Materials Structures.**  
*Author: Muhannad Al-Waily (ISBN 13: 978-1-50588-564-4)*

**BOOK: Engineering Applications of Computational Fluid Dynamics: Volume 3.***Editor: Maher A.R. Sadiq Al-Baghdadi**(ISBN 13: 978-1-51178-878-6)***BOOK: Engineering Applications of Computational Fluid Dynamics: Volume 4.***Editor: Maher A.R. Sadiq Al-Baghdadi**(ISBN 13: 978-1-51197-480-6)***BOOK: Applications of Computational Fluid Dynamics and Finite Element Methods in Engineering Education: Volume 1.***Author: Maher A.R. Sadiq Al-Baghdadi**(ISBN 13: 978-1-51212-242-8)***BOOK: Engineering Applications of Computational Fluid Dynamics: Volume 5.***Editor: Maher A.R. Sadiq Al-Baghdadi**(ISBN 13: 978-1-54035-259-0)***BOOK: Physical modeling of PIANO KEY weir: Detailed experimental study.***Author: Mohammed Baqer N. Al-Baghdadi**(ISBN 13: 978-1-53971-134-6)***BOOK: Analytical and Experimental Investigations Vibration Study of Isotropic and Orthotropic Composite Plate Structure with Various Crack Effect.***Author: Muhannad Al-Waily**(ISBN 13: 978-1-54403-151-4)***BOOK: Materials Science and Engineering.***Author: Noor Hussein**(ISBN 13: 978-1-54408-380-3)***BOOK: PEM Fuel Cell Engines: Principles, Design, Modelling, and Analysis.***Author: Maher A.R. Sadiq Al-Baghdadi**(ISBN 13: 978-1-98347-499-6)***BOOK: Progress in River Engineering & Hydraulic Structures: Volume 1.***Editor: Mohammed Baqer N. Al-Baghdadi**(ISBN 13: 978-1-98520-206-1)***BOOK: Progress in River Engineering & Hydraulic Structures: Volume 2.***Editor: Mohammed Baqer N. Al-Baghdadi**(ISBN 13: 978-1-72759-365-5)*