

Paulo Sérgio Duque de Brito ·  
João Rafael da Costa Sanches Galvão · Pedro Monteiro ·  
Roberta Panizio · Luís Calado · Ana Carolina Assis ·  
Filipe dos Santos Neves · Flávio Craveiro ·  
Henrique de Amorim Almeida · Joel Oliveira Correia Vasco ·  
Ricardo de Jesus Gomes · Sandra de Jesus Martins Mourato ·  
Vânia Sofia Santos Ribeiro *Editors*

# Proceedings of the 2nd International Conference on Water Energy Food and Sustainability (ICoWEFS 2022)

Proceedings of the 2nd International Conference  
on Water Energy Food and Sustainability  
(ICoWEFS 2022)

Paulo Sérgio Duque de Brito ·  
João Rafael da Costa Sanches Galvão ·  
Pedro Monteiro · Roberta Panizio · Luís Calado ·  
Ana Carolina Assis · Filipe dos Santos Neves ·  
Flávio Craveiro · Henrique de Amorim Almeida ·  
Joel Oliveira Correia Vasco ·  
Ricardo de Jesus Gomes ·  
Sandra de Jesus Martins Mourato ·  
Vânia Sofia Santos Ribeiro  
Editors

# Proceedings of the 2nd International Conference on Water Energy Food and Sustainability (ICoWEFS 2022)

*Editors*

Paulo Sérgio Duque de Brito  
School of Technology and Management  
Polytechnic Institute of Portalegre  
Portalegre, Portugal

João Rafael da Costa Sanches Galvão  
School of Technology and Management  
Polytechnic of Leiria  
Leiria, Portugal

Pedro Monteiro  
Polytechnic Institute of Portalegre  
Portalegre, Portugal

Roberta Panizio  
School of Technology and Management  
Polytechnic Institute of Portalegre  
Portalegre, Portugal

Luís Calado  
School of Technology and Management  
Polytechnic Institute of Portalegre  
Portalegre, Portugal

Ana Carolina Assis  
School of Technology and Management  
Polytechnic Institute of Portalegre  
Portalegre, Portugal

Filipe dos Santos Neves  
School of Technology and Management  
Polytechnic of Leiria  
Leiria, Portugal

Flávio Craveiro  
School of Technology and Management  
Polytechnic of Leiria  
Leiria, Portugal

Henrique de Amorim Almeida  
School of Technology and Management  
Polytechnic of Leiria  
Leiria, Portugal

Joel Oliveira Correia Vasco  
School of Technology and Management  
Polytechnic of Leiria  
Leiria, Portugal

Ricardo de Jesus Gomes  
School of Technology and Management  
Polytechnic of Leiria  
Leiria, Portugal

Sandra de Jesus Martins Mourato  
School of Technology and Management  
Polytechnic of Leiria  
Leiria, Portugal

Vânia Sofia Santos Ribeiro  
School of Health Sciences  
Polytechnic of Leiria  
Leiria, Portugal

ISBN 978-3-031-26848-9

ISBN 978-3-031-26849-6 (eBook)

<https://doi.org/10.1007/978-3-031-26849-6>

© The Editor(s) (if applicable) and The Author(s), under exclusive license  
to Springer Nature Switzerland AG 2023

This work is subject to copyright. All rights are solely and exclusively licensed by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publisher, the authors, and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, expressed or implied, with respect to the material contained herein or for any errors or omissions that may have been made. The publisher remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

This Springer imprint is published by the registered company Springer Nature Switzerland AG  
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

# Preface

The second **International Conference on Water, Energy, Food and Sustainability (ICoWEFS 2022)**, taking place in Portalegre (May 10–12, 2022), Portugal, aims to be a major forum to foster innovation and exchange knowledge in the water-energy-food nexus, embracing the Sustainable Development Goals (SDGs) of the United Nations, bringing together leading academics, researchers and industrial experts. The conference expects to foster networking and collaboration among participants to advance the knowledge and identify major trends in the abovementioned fields.

The world is facing unprecedented challenges to mitigate climate change and adapt to its negative impacts, affecting the global economy and society. Europe intends to take the lead on the transition to sustainability, as a chief priority of Horizon Europe is a European Green Deal to transform Europe in a climate-neutral continent, fostering disruptive innovation and the deployment of new technologies and innovative solutions, helping to create a sustainable future.

Innovation regarding water, energy, agri-food, bio-economy, natural resources and environment will speed up the transition toward sustainability, promoting water and food security in the world.

A climate-neutral continent by 2050 will drive technological, economic and societal transformations toward circular economies and green and clean technologies and the decarbonization of energy-intensive industries.

The conference will be a networking and collaboration among participants to advance the knowledge and identify major trends in the fields mentioned above, even in an online format according to the health rules.

We are grateful to the authors from 16 countries with their contribution of 55 papers accepted to be presented at ICoWEFS 2022 and published by Springer Nature, to the directors and staff of the Polytechnic of Portalegre and the Polytechnic of Leiria for their support, to the research centers and sponsoring companies, to the members of the scientific committee and external reviewers, keynote speakers and, finally, to the members of the organization, who with redoubled efforts during a pandemic time managed to carry out this conference.

We hope that we can meet again at the next ICoWEFS Conference.



Paulo Brito  
João Galvão  
Conference Chairs

# Organization

## Conference Co-chairs



Paulo Sérgio Duque de Brito  
Polytechnic of Portalegre, Portugal



João Rafael da Costa Sanches Galvão  
Polytechnic of Leiria, Portugal

## Organizing Committee



Ana Carolina Assis  
Portalegre Polytechnic



Catarina Nobre  
Portalegre Polytechnic



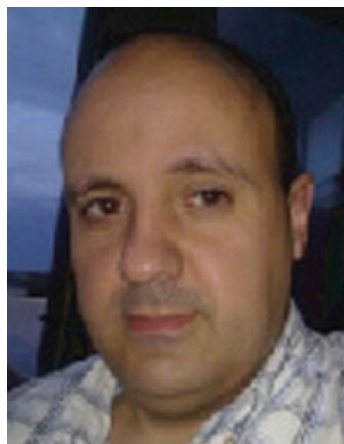
Filipe Neves  
Leiria Polytechnic



Flávio Craveiro  
Leiria Polytechnic



Henrique Almeida  
Leiria Polytechnic



Joel Vasco  
Leiria Polytechnic



Luis Calado  
Portalegre Polytechnic



Pedro Monteiro  
Portalegre Polytechnic



Ricardo Gomes  
Leiria Polytechnic



Roberta Panízio  
Portalegre Polytechnic



Sandra Mourato  
Leiria Polytechnic



Vânia Ribeiro  
Leiria Polytechnic

## Scientific Committee

Abel Rodrigues	INIAV/Research Institute, Portugal
Ahmad Pourmovahed	Kettering University, Michigan, USA
Alfeu Sá Marques	Coimbra University, Portugal
Ana Gomes	ESB-UCP/Catholic University, Portugal
Ana Vale	School of Science IT Sligo, Ireland
Anukka Pakarinen	HAMK University, Finland
Antonio Macías	Extremadura University, Spain
Carla Ferreira	ESAC/Coimbra Polytechnic, Portugal
Carlos Borrego	Aveiro University, Portugal
Carlos Henggeler	INESCC/Coimbra University, Portugal
Eduardo Álvarez	Oviedo University, Spain
Eliseu Monteiro	Coimbra University, Portugal
Fausto Freire	Coimbra University, Portugal
Fernando Lidon	Nova University, Portugal
Hassan El Bari	Ibn Tofail University, Kenitra, Morocco
Helena Bártoło	Leiria Polytechnic, Portugal
Henrique de Amorim Almeida	Leiria Polytechnic, Portugal
Howard Dryden	GOES Foundation, Edinburgh University, Scotland, UK
Jerónimo Cortés	CICTE/Extremadura, Research Center Spain
John Cosgrove	Limerick Institute of Technology, Ireland
João Pina	FCT/Nova Lisbon University, Portugal
Joaquim Sousa	Coimbra Polytechnic, Portugal
Jorge MGP Isidoro	Algarve University, Portugal
José Lobo	Extremadura University, Spain
Kirsi Knuuttila	JAMK University, Finland
Lisiane Librelotto	Universidade Federal de Santa Catarina, Florianópolis, Brasil
Lucélia Hoehne	Universidade do Vale do Taquari, UNIVATES, Brasil
Luís Loures	VALORIZA/Portalegre Polytechnic, Portugal
Luís Neves	INESC/Leiria Polytechnic, Portugal
Luís Silva	Porto Polytechnic, Portugal
Luís Tarelho	Aveiro University, Portugal
Luísa Schmidt	ICS/Lisbon University, Portugal
Madalena Moreira	Évora University, Portugal
Manuel Jesús Hermoso Orzáez	Universidad de Jaén, Spain
Margarida Gonçalves	Nova University, Portugal
María Hernández	Extremadura University, Spain
Marika Tossavainen	HAMK University, Finland

Marina Antunes	ISCAL/Lisbon Polytechnic, Portugal
Marritta Kymalainen	HAMK University, Finland
Milica Kasanin-Grubin	University of Belgrade, Serbia
Mohammed Benhachmi	Faculté des Sciences et Techniques de Mahammedia, Morocco
Nicolau Almeida	Portalegre Polytechnic, Portugal
Noel Perera	Birmingham City University, UK
Nuno Simões	Coimbra University, Portugal
Ramón Sanguino	Extremadura University, Spain
Remco Kranendonk	Wageningen University and Research, Netherlands
Ricardo Chacartegui	Sevilha University, Spain
Rodrigo Moruzzi	UNESP/São Paulo State University, Brazil
Rui Ganhão	Leiria Polytechnic, Portugal
Saifur Rahman	Virginia Tech Advanced Research Institute, USA
Sérgio Leitão	UTAD/Trás-os-Montes e Alto Douro University, Portugal
Sónia Pereira	Leiria Polytechnic, Portugal
Susana Neto	IST/Lisbon University, Portugal
Teresa Mouga	Polytechnic of Leiria, Portugal
Valentim Realinho	VALORIZA/Portalegre Polytechnic, Portugal
Zahra Kalantari	Stockholm University, Sweden

## Conference Sponsors

The conference co-chairs and organizing committee wish to acknowledge the support and sponsorship given in the organization of the ICOWEFS 2022 – International Conference on Water Energy Food and Sustainability, held at the Polytechnic Institute of Portalegre, Portugal.

## Official Sponsors





## ICoWEFS 2022 is Organized in Cooperation with These Research Units



## Event Sponsors and Exhibitors

