



CIEEMAT` 22

CIEEMAT 2022

VII Ibero-American Congress on  
Entrepreneurship, Energy,  
Environment and Technology

Book of Abstracts

6-8 July 2022  
Bragança, Portugal



**CIEEMAT 2022 - VII Ibero-American Congress on  
Entrepreneurship, Energy, Environment and Technology  
Book of Abstracts**

6-8 July 2022

**Editors**

Ângela Ferreira, Instituto Politécnico de Bragança  
Carla Sofia Fernandes, Instituto Politécnico de Bragança  
Florbela Fernandes, Instituto Politécnico de Bragança  
Luís Pais, Instituto Politécnico de Bragança

Instituto Politécnico de Bragança – 2022  
Campus de Santa Apolónia  
5300-253 Bragança, Portugal

ISBN: 978-972-745-305-4

Book Cover: Soraia Maduro, Instituto Politécnico de Bragança

## **ABOUT THE EVENT**

The VII Ibero-American Congress on Entrepreneurship, Energy, Environment and Technology (VII CIEEMAT), coordinated by the Federal Centre of Technological Education from Rio de Janeiro (CEFET/RJ), was held for the third time in Portugal, and for the second time in the city of Bragança, under the organization of the Polytechnic Institute of Bragança (IPB), the Research Centre in Digitalization and Intelligent Robotics (CeDRI), the Mountain Research Centre (CIMO) and the Associated Laboratory for Sustainability and Technology in Inland Regions (SusTEC). The event aims to consolidate the Luso-Brazilian and Ibero-American cooperation in those areas, gathering the multinational contribution and enhancing collaboration in academic and scientific fields.

The VII CIEEMAT took place on July 6-8, 2022 and had the Energy Transition as its specific theme. The current energy context and the transition of energy generation and consumption typologies are unavoidable in defining the profiles of national and international societies and energy policies. The dynamism to which the energy sector is currently subjected is imposed by environmental and safety concerns, the fluctuation of the fossil fuels price and shifting technologies, which translates into challenges and opportunities across various sectors as research and innovation, education, policy and environmental governance. The opportunities and challenges of the energy transition are outlined, for instance, in the exploitation of natural assets, the decarbonisation of the economy and the transport sector and the flexibility of energy infrastructure through smart grids.

The VII CIEEMAT followed a program addressing various perspectives of action of higher education institutions and R&D units and their cooperation with society: i) the academic perspective (why, what and how to teach the challenges of energy transition); ii) the perspective of international cooperation, defining new cooperation programs between Portugal and Brazil in the energy field, with emphasis on the Brazilian EnergIF program and its potential for international cooperation with Portugal; iii) and the research and innovation perspective, with the contribution of academic experts and the business sector regarding the challenges that the necessary and emerging energy transition poses.

At the same time, the VII CIEEMAT provided also a forum to disseminate and share ongoing research in various academic and scientific institutions, through oral communications in the areas of sustainable urban mobility, energy generation and self-consumption, environmental challenges, decarbonisation and climate change.

## COMMITTEES

### **Organizing Committee**

Luís Pais, IPB  
Marco Juliatto, SETEC-MEC  
Ronney Boloy, CEFET/RJ  
Ângela Ferreira, IPB  
Artur Gonçalves, IPB  
Carla Sofia Fernandes, IPB  
Florbela Fernandes, IPB  
João Azevedo, IPB  
José Luís Lima, IPB  
Ana Carolina Lima, IPB

### **Scientific Committee**

Ana Queiroz da Silva, IPB, Portugal  
Ângela Ferreira, IPB, Portugal  
António Castro Ribeiro, IPB, Portugal  
António Valente, UTAD, Portugal  
Arlindo Ferreira de Almeida, IPB, Portugal  
Artur Gonçalves, IPB, Portugal  
Carla Fernandes, IPB, Portugal  
Daniel de Cerqueira Santos, IFPE, Brasil  
Florbela Fernandes, IPB, Portugal  
Gabriel Pinto, UMinho, Portugal  
Gardênia Mendes de Assunção, CEFET/RJ, Brasil  
Ian Mateo Sosa, ITSON, México  
João Azevedo, IPB, Portugal  
João Miranda de Castro, IPB, Portugal  
José Luís Lima, IPB, Portugal  
Laene Oliveira Soares, CEFET/RJ, Brasil  
Laíce de Souza Scotelano, CEFET/RJ, Brasil  
Luis Hernandez Callejo, UVa, Espanha  
Manuel Sabença Feliciano, IPB, Portugal  
Marcos Vallim, UTFPR, Portugal  
Margarida Arrobas Rodrigues, IPB, Portugal  
Orlando Soares, IPB, Portugal  
Paulo Brito, IPB, Portugal  
Paulo Cicero Fritzen, UTFPR, Brasil  
Ronney Boloy, CEFET/RJ, Brasil  
Sara Paiva, IPVC, Portugal  
Thiago Machado Bazzo, UTFPR, Brasil  
Vanessa de Almeida Guimarães, CEFET/RJ, Brasil

# CONTENTS

<b>About the Event</b> .....	<b>i</b>
<b>Committees</b> .....	<b>ii</b>
<b>Contents</b> .....	<b>iii</b>
Building of Smart Plugs to Energy Efficiency in the Residence Load Management .....	1
Smart System for Monitoring and Controlling Energy Consumption and Ambient Conditions.....	3
Smart Buildings – A Case Study in Braganza .....	5
Simulated Microcontrolled Photovoltaic Irrigation System for Family Farming .....	7
Microgrid Integration: An Opportunity that Need Challenges .....	9
Wind Turbine Data Visualization Based on Principal Component Analysis .....	11
Brazilian PV Power Converter Substations.....	13
Analysis of the Synergy Between Consumption and Residential Photovoltaic Production in the City of Três Lagoas – MS .....	15
Comparison Between the Analysis of Measured and Simulated Performance Ratio of Photovoltaic Microgeneration System.....	17
Biodiesel Production from Waste Cooking Oils Catalysed by Ionic Liquid [BMIM][HSO <sub>4</sub> ] .....	19
Valorisation of Waste Cooking Oils through Conversion Processes to Biodiesel Catalysed by Ionic Liquid [HMIM][HSO <sub>4</sub> ] .....	21
Modeling Residual Wood Biomass Yield in the Sub-Regions Terras de Trás-os-Montes and Aveiro ..	23
Study of Biodiesel Production from Waste Cooking Oil by Ethyl Transesterification and its Purification Using Adsorption Processes .....	25
Biodiesel Production from Residual Cooking Oils and Purification by Adsorption Processes Based on Adsorbents of Natural Origin .....	27
Biomass Characterization and Pyrolysis, the Effect of Heating Rate on Products Yield .....	29
Metal Oxide-Based Photoelectrocatalytic Materials for Overall Water Splitting: An Overview .....	31
Construction and Characterization of Solar Cells Sensitized by Natural Dyes Extracted from Fruits and Flowers .....	33
Main Changes of the New Regulatory Framework of Distributed Generation in Brazil and Future Prospects.....	35
Practical Effect of Time on Solar Energy Generation Based on Thermoelectric Effect .....	37
Environmental Impacts by Outdoor Activities in Northern Portugal.....	39
Municipal Solid Waste Biorefineries: A State-of-the-Art .....	41
Wind Turbine Blade Waste: A Quantifying Model .....	43
Numerical Investigation of Contaminant Distribution in a Room .....	45
Becoming Acquainted with Green Roofs Contribution Towards Circular and Resilient Cities .....	47

Environmental Assessment of an Urban Wastewater Treatment Plant by Calculating the Carbon Footprint .....	49
An Analysis of the Relationship Between Working from Home and Environmental Impacts.....	51
Urban Green Space Conservation: An Approach Within the Scope of Environmental Education .....	53
Life Cycle Analysis and Kaizen in an Educational Institution: A Systematic Literature Review and Bibliometric Analysis .....	55
Waste Collection Problem Solution Using Open-Source Tool .....	57
Adaptive System to Manage Everyday User Comfort Preferences .....	59
Potential Reduction of Greenhouse Gas Emissions Through Vehicle Electrification: A Bibliometric Analysis .....	61
Technological Perspectives and Economic Aspects of Green Hydrogen in the Energetic Transition: Challenges for Chemistry .....	63
Activity of Carbon Black/PTFE Composites Materials for Electrochemical Hydrogen Peroxide Production.....	65
Occurrence of Polycyclic Aromatic Compounds in Different Environmental Compartments Around a large Brazilian Tropical Bay .....	67
CO2 Fluxes through the Atmosphere/Grass Interface in an Urban Green Space Located in the North Interior of Portugal.....	69
Electric Vehicle Supply Chain Management: A Bibliometric and Systematic Review .....	71
Smart Living, a Way for Sustainability and Culture 4.0 .....	73
Mobi2verde: A Sustainable Urban Mobility Proposal to Serve Public Network Students in Brazil .....	75
Reduction of GHG Emissions from Electric Mobility Penetration: a Study Case in Sal Island .....	77

# Wind Turbine Blade Waste: A Quantifying Model

Lucas Lisboa<sup>1</sup> [0000-0002-0255-4862], Luís Frólén Ribeiro<sup>1,2</sup> [0000-0003-4336-6216]

<sup>1</sup> Instituto Politécnico de Bragança, Portugal

<sup>2</sup> INEGI-LAETA, 4200-465 Porto, Portugal  
a46705@alunos.ipb.pt; frolen@ipb.pt

## Abstract

The growing trend of renewable energy, while helping decentralise and diversify the current energetic matrix, may also bring opportunities for improvement. Until today, a vital part of the wind turbine does not have a solidified disposal method in its afterlife. To better assess this issue, one needs to quantify it. A model based on actual wind turbine data enabled high accuracy estimation of the existing waste and predicted what will be generated in the industry's future.

Between 2000 and 2014, the wind was the type of energy that registered the most considerable growth – not just among the renewable, but overall (15% more than second-placed gas) [1]. In the current European Union's plan to achieve net-zero emissions in its energy system by 2050, wind energy will play a relevant role: it expects a continuously grow in installed capacity of 17% until 2025, followed by a 12% one by 2030 [2]. However, what environmental impact can this measure and similar ones induce?

Most wind turbine composition is from recyclable materials (94%); the issue lies in the remainder: the blades, mostly made of composites and resins – challenging to recycle materials [3].

One must take a step back and analyse some data to understand better how much of a concern it can become in the following years. In this paper, one analysed 357 distinct accurate wind turbine blade models from different manufacturers with rated power from 65 kW to 14 MW to attain enough data to create a model to predict the future waste generated by decommissioned wind turbine blades. The primary source of technical information was obtained through a wind turbine model database [4].

As a result, one developed a model to predict with a high resolution – compared to similar works from several authors – what the future holds regarding wind turbine blade waste.

Instead of plotting all the data points in a scatter graph and using the resulting trendline to calculate an equation based on linear regression, the rated power range was divided into 10 intervals to offer a better resolution, Figure 1.

One used a data set published by Wind Europe [5] as an exercise in the practical use of this model. In it, we have the total output of offshore wind turbines installed in Europe between 1995 and 2022. By applying the median (to filter outliers in the data) results seen on each rated power interval in Figure 2 to the number of installed turbines in the respective bin. One estimates the result of 27 years of wind turbine operations: 333.936,15 tons of waste with no current solution besides landfilling or incineration.

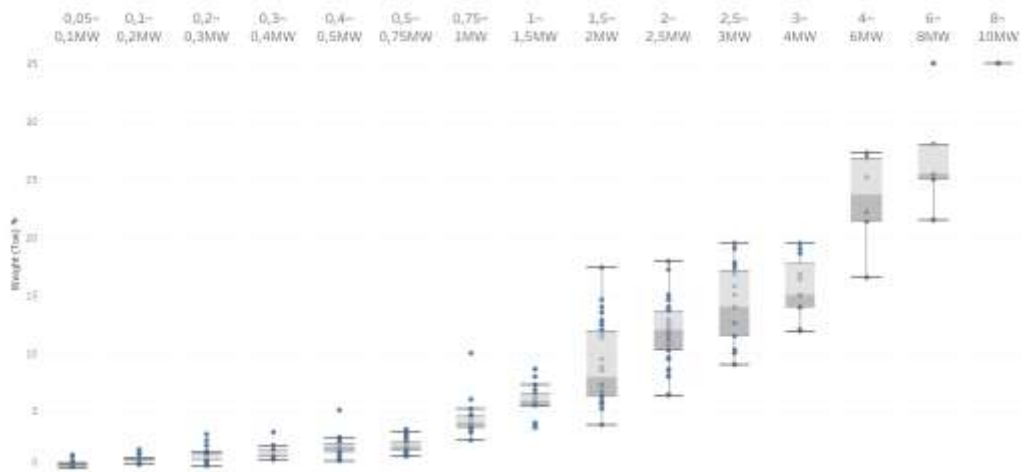


Figure 1 - Weight distribution by rated power

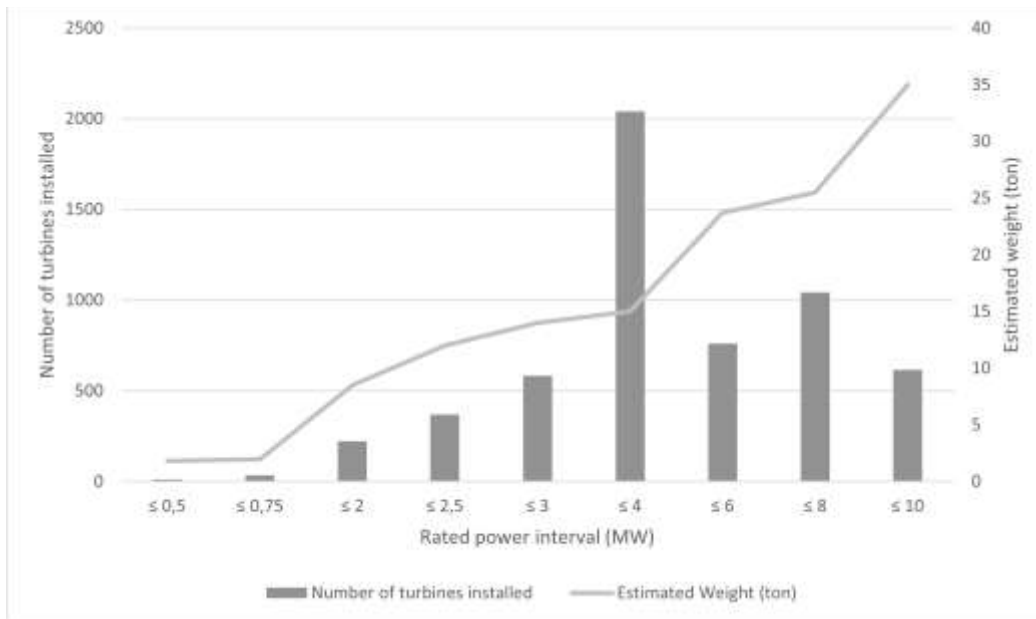


Figure 2 - Estimated weight of offshore turbines in Europe

**Keywords:** Wind turbine blade, waste, model.

## References

- [1] GWEC – Global Wind Energy Council. Global wind report – annual market update 2014. (2014). pp. 45.
- [2] European Commission. Towards net-zero emissions in the EU energy system by 2050. (2020).
- [3] Beauson, J., Bech, J. I., Brøndsted, P. (2014). Composite recycling: Characterising end of life wind turbine blade material. In Proceedings of 19th International Conference on Composite Materials.
- [4] Bauer, L. and Matysik S. (2022). Wind-Turbine-Models. Available at <<https://en.wind-turbine-models.com/>>. Accessed on 22 June 2022.
- [5] Wind Europe. European Offshore Wind Farms Map Public. Available at < <https://windeurope.org/intelligence-platform/product/european-offshore-wind-farms-map-public/>>, Accessed on 25 June 2022.