ME3 MEETING on ENERGY and ENVIRONMENTAL ECONOMICS

8th Meeting on Energy and Environmental Economics – ME3

Book of Extended Abstracts

"Energy Poverty"

universidade de aveiro
theoria poiesis praxis

Title:
8th Meeting on Energy and Environmental Economics - Energy Poverty - Book of Extended Abstracts

Editors:
Mara Madaleno
Margarita Robaina
Marta Ferreira Dias
Anabela Botelho

Publisher:
UA Editora - Universidade de Aveiro
1st Edition – July 2023

ISBN:
978-972-789-867-1

DOI:
https://doi.org/10.48528/v3b3-fk78

Index

Welcome

8th May 2023

University of Aveiro, DEGEIT, Aveiro, Portugal

Call for Papers (until 30th April)

Dear Colleagues,

We cordially invite you to participate in the Eight Meeting on Energy and Environmental Economics (ME3). The event is going to be organized in a **hybrid mode** on the morning of the **8th of May 2023** by the GOVCOPP and DEGEIT, UA.

The ME3 is an international meeting, which aims at sharing experiences and results by the Scientific and Business community whose interests are the Economics of Energy and the Environment. In particular, young researchers in energy are crucial to help address Europe's challenges in the energy field. Therefore, the meeting hopes to attract Ph.D. and MSc students interested in these topics and to give them a floor to show their work, at any stage of their work. The event will have scientific sessions and a round table with main stakeholders concerning the main topic of the Meeting this year: **Energy Poverty**. On the Round Table, we will have representatives from ongoing scientific research projects, to discuss the economic relevance of environmental and energy problems solutions.

Preliminary program (8th May 2023):

9h00 – 10h00: Scientific Sessions

10h00 – 10h45: Keynote Speaker: João Pedro Gouveia (Firefly, CENSE, FCT-NOVA)

Exploring Energy Poverty at Multiple Scales: Policies, Research and On the Ground Action

Presentation will address the research, methods and analysis, social and policy impact of multiple national and international projects on energy poverty. The presentation will disclose multiple level analysis relevant for supporting different agents (local & national governments, NGO's, etc.) to address energy poverty.

João Pedro Gouveia holds PhD in Climate Change, and Sustainable Development Policies. He is the head of the Firefly lab and a Senior Researcher at the Center for Environmental and Sustainability Research (CENSE) where he leads research on buildings energy efficiency, energy poverty, climate change mitigation and adaptation. He is also an invited professor at FCT - NOVA University of Lisbon and at ISEC Lisbon. João Pedro is part of the Coordination team of EPAH - EU Energy Poverty Advisory Hub from the European Commission.

10h45 – 11h00: Coffee-Break

11h00 – 12h00: Scientific Session

12h00 – 13h15: Round Table: **Economic Relevance in Environmental and Energy problems solutions**

João Matias (GOVCOPP, DEGEIT, UA) -Project BioAgroFlores https://BioAgroFlores.web.ua.pt

Luís Tarelho (CESAM, DAO, UA) – Project Biovalchar https://biovalchar.web.ua.pt/

Margarita Robaina (GOVCOPP. DEGEIT, UA) – Project R3EA r3ea (ua.pt)

Call for Papers

Short Papers (max. 5 pages) and Long Abstracts (max. 2 pages) can be submitted until 30th April 2023 using the following email: **degei-me3@ua.pt** using the **template** attached to this email.

The best presentation by Master or PhD students, will be awarded by the Portuguese Association of Energy Economics **(APEEN)** with a **monetary prize of 250€.**

Although the main thematic is Energy Poverty, the conference welcomes submissions in the **following areas** but not limited to:

ECONOMICS: Macro events impact (War; COVID-19; etc.) and Economy; Application of Environment Kuznets Curve with new Approaches; Carbon Tax Policies; Circular Economy; Energy Communities and Economic Development; Economics of Energy Systems; Econometrics, Energy Markets and Ecological Footprints, Energy and Cost Saving Potential; Economic Aspects of Climate Change and Environment; Economics and Policy Issues related to Mineral and Fossil Fuel; Energy Markets and the Macroeconomic Indicators; Financialization and Energy Markets; Food Economy; Household's Willingness to Pay; International Trade, Energy and Environment; Monetary Policy, Energy and Environment; Mineral Economics; Policy and Economics of Renewable Energy and Environment; Waste Economy and Waste Exchange; Other interesting topics.

ENERGY: Macro events impact (War; COVID-19; etc.) and Energy Market; Technology and Renewable Energy; Energy Planning, Modelling and Forecasting; Economics and Policy of Energy; Electricity/Natural Gas Storage; Energy and Sustainability; Energy Efficiency and Conservation; Energy Finance: Frontiers and Future Development; Energy Prices-Macro Economic Performance Relationship; Energy Resources and Sustainable Development; Energy Supply Reliability and Security; Energy Systems and Smart Grids; Food-Agriculture-Energy Nexus; Globalization and Energy; Innovation in Resource Management; Photovoltaic (and other renewable) Systems; Sustainable Energy Cities and Communities; Renewable and Non-renewable Energy Sources; Other interesting topics.

ENVİRONMENT: Macro events impact (War; COVID-19; etc.) and Environment; Agriculture-Food-Environment Nexus; Air pollution and treatment; Climate, Trade, Development and Policy; Ecology, Ecosystems and Landscape; Environmental Change and Statistical Ecology; Environmental Protection and Paris Agreement; Environmental Safety Regulations; Environmental Sustainability and Development; Environmental Assessments and Management of Chemicals; Environmental Impacts of Alternative Energy Sources; Environmental Health Statistics; Greenhouse Effect, Global Warming, and Climate Change; Impact of Industrialization on the Environment; Soil Pollution, Water Pollution and Treatment; Solid Waste and Wastewater Management; Pollution and Health Issues; Transport and Environment; Other interesting topics.

The short papers will be published in a **digital book** (if authorized by authors) with ISBN.

Each submission should be a single PDF with a maximum size of 3MB. The number of submissions is limited to two and the number of presentations to one, by author. The official language of the ME3 is English.

All papers will undergo a review process and decisions on acceptance or rejection of the submitted works will be taken no later than May 3, 2023.

Authors of accepted papers must register at ME3 before May 5th, 2023. Only papers of registered authors will be included in the program. Payment instructions will be sent by email. **Presentation of papers can be done in presence or remotely**.

Important Dates:

- **Call for papers:** until **30th April**
- **Disclosure of accepted articles: 3rd May**
- **Registration until 5th May:** Students: 10€ /No student: 35€

Link for payment and registration: aqui ; https://forms.gle/vAR1CsuvMC1eKMoq7

Organizing Committee: *Chair (University of Aveiro)*: Mara Madaleno

Members, Co-chairs (University of Aveiro): Anabela Botelho; Margarita Robaina; Marta Ferreira Dias.

APEEN Associação Portuguesa de Economia da Energia

IAEE International Association for Energy Economics www.iaee.org

govcopp

Objetives

Session on Energy Poverty and Round Table with projects on Energy and Environment developed at the UA in the 8th Edition of ME3.

Included in the program of the 8th edition of the Meeting on Energy and Environmental Economics (ME3), we will receive João Pedro Gouveia (Firefly, CENSE, FCT-NOVA) as a Keynote Speaker, on May 8 at 10 am, with the theme: Exploring Energy Poverty at Multiple Scales: Policies, Research and Action on the Ground.

The presentation will address the research, methods and analyses, social and political impact of several national and international projects on energy poverty. It will also disseminate relevant multi-level analyzes to support different actors (local and national governments, NGOs, etc.) to address energy poverty.

The Conference will also feature a Round Table on the Importance of Economics in Solving Energy and Environment Problems with the presentation of research projects to be developed at the University of Aveiro, namely:

BioAgroFlores Project https://BioAgroFlores.web.ua.pt, **Biovalchar** Project https://biovalchar.web.ua.pt/ and the **R3EA** Project https://r3ea.web.ua.pt/.

ME3 is an international meeting, which aims to share experiences and results by the Scientific and Business community with interests in Economics of Energy and the Environment. In particular, young energy researchers are crucial in helping to address Europe's energy challenges. Therefore, the meeting hopes to attract Ph.D. and Master's students interested in these themes and give them the floor in scientific sessions to communicate their work, at any stage of development. The sessions will take place in hybrid mode at DEGEIT on May 8, 2023.

The entire academic community is invited to attend, but must register via email: degei-me3@ua.pt

Committees

Organizing Committee

Chair (University of Aveiro)
Mara Madaleno

Members, Co-chairs (University of Aveiro)
Anabela Botelho; Margarita Robaina; Marta Ferreira Dias

Scientific Committee

Anabela Botelho - University of Aveiro
António Marques - University Beira Interior
Catarina Roseta Palma - ISCTE-IUL
Daniel Magueta - University of Aveiro
Isabel Soares - FEP - University of Porto
João Lagarto - ISEL
João Matias - University of Aveiro
João Pedro Gouveia - FCT-UNL
Jorge Sousa - ISEL
Júlia Seixas - FCT-UNL
Luís Tarelho - University of Aveiro
Mara Madaleno - University of Aveiro
Marieta Valente - University of Minho
Margarita Robaina - University of Aveiro
Marta Ferreira Dias - University of Aveiro
Mónica Meireles - ISCTE-IUL
Nélson Martins - University of Aveiro
Nuno Figueiredo - Trustenergy
Patrícia Pereira da Silva - Faculty of Economics –Univ. of Coimbra
Paula Ferreira - University of Minho
Pedro Macedo - University of Aveiro
Rita Sousa - University of Minho

Conference Chair and Co-chairs

Mara Madaleno, DEGEIT, GOVCOPP

Margarita Robaina, DEGEIT, GOVCOPP

Marta Ferreira Dias, DEGEIT, GOVCOPP

Anabela Botelho, DEGEIT, GOVCOPP

Organização local:

Mara Madaleno, Anabela Botelho, Margarita Robaina, Marta Ferreira Dias

Program

8th May 2023

University of Aveiro, DEGEIT

Aveiro, Portugal

9h00 – 10h00: Scientific Sessions

A- Energy Innovation *(online)*

Chair: Mara Madaleno
link: https://videoconf-colibri.zoom.us/j/94079183124?pwd=Q00zWU0xYk5WY25vQW53OTMrK1JLZz09
room: 10.1.16

- USING ARTIFICIAL INTELLIGENCE TO CREATE A RENEWABLE ENERGY SENTIMENT INDEX FOR AUSTRALIA
  Xi Li, Stefan Trück
- AN ANALYSIS OF PRICE-SETTING GENERATION TECHNOLOGIES IN THE AUSTRALIAN NATIONAL ELECTRICITY MARKET
  Santosh Sapkota, Lin Han, Stefan Trück
- EXPLAINABLE ARTIFICIAL INTELLIGENCE (XAI) FOR ENERGY POVERTY ANALYSIS: A SPANISH CASE OF STUDY
  Miguel Angel Rios, Ignacio Segarra Tamarit, Roberto Barrella
- PERFORMANCE OF GREEN AND CONVENTIONAL FUNDS: EVIDENCE FOR PORTUGUESE FUNDS
  Elisabete Neves, Diana Santos
- NON-RESIDENTIAL HARD-TO-REACH ENERGY USERS: A VAST AUDIENCE FORGOTTEN BY THE ENERGY TRANSITION?
  Miguel Macias Sequeira, João Pedro Gouveia

B- Energy Transition *(hybrid)*

Chair: Margarita Robaina
link: https://videoconf-colibri.zoom.us/j/91547292878 room: 10.2.2

- ASSESSING THE LITERATURE ON ENERGY TRANSITION AND ECONOMICS IN LATIN AMERICA: AN IMPACT AND CENTRALITY ANALYSIS
  Vitor Benfica, António Cardoso Marques *(presencial)*
- CONSEQUENCES OF THE ENERGY TRANSITION ON POVERTY AND DEPENDENCE IN COUNTRIES IN THE SADC REGION: AN ANALYSIS OF PANEL DATA FROM 2000-2021
  Querubim Capimolo Lucamba, António Cardoso Marques, Diogo André Pereira *(presencial)*
- EXPLORING PERCEPTIONS OF COMPETING AGENDAS IN PORTUGUESE CARBON NEUTRALITY POLICIES

Katherine Mahoney, João Pedro Gouveia, Rita Lopes, Siddharth Sareen *(online)*

- ASSESSING THE ECONOMIC IMPACTS OF THE CHILEAN ENERGY TRANSITION: AN INPUT-OUTPUT HYBRID EQUILIBRIUM MODEL, Tomás Ochoa, Diego Vera, Esteban Gil, George Kerrigan, Víctor Hinojosa *(online)*
- RENEWABLE ENERGIES INVESTMENT IN EUROPEAN COUNTRIES – THE CASE OF PORTUGAL (SOLAR AND WIND)
  Max López-Maciel, Edimar Ramalho, Mara Madaleno, José Villar, André de Oliveira, Marta Ferreira Dias, Anabela Botelho, Margarita Robaina *(presencial)*

10h00 – 10h45: Keynote Speaker:

João Pedro Gouveia (Firefly, CENSE, FCT-NOVA)

EXPLORING ENERGY POVERTY AT MULTIPLE SCALES: POLICIES, RESEARCH AND ON THE GROUND ACTION

Chair: Marta Ferreira Dias
link: https://videoconf-colibri.zoom.us/j/94079183124?pwd=Q00zWU0xYk5WY25vQW53OTMrK1JLZz09; room: 10.2.2

10h45 – 11h00: Coffee-Break *room: 10.1.16*

11h00 – 12h15: Scientific Sessions

A- Energy efficiency, renewables and sustainability *(hybrid)*

Chair: Marta Ferreira Dias

link: https://videoconf-colibri.zoom.us/j/91547292878 ; room: 10.2.2

- DO SUSTAINABILITY AND GREEN PRACTICES REDUCE COSTS IN THE PORK SUPPLY CHAIN
  Sebastiano Bacca, Rita Sousa, Daniela Campos *(presencial)*
- A GLOBAL REVIEW OF SUSTAINABILITY REPORTING IN THE ENERGY SECTOR
  Connor Guilherme, Patrícia Pereira da Silva and Susana Jorge *(presencial)*
- ENERGY EFFICIENCY IMPROVEMENTS IN A PORTUGUESE CERAMIC INDUSTRY: CASE STUDY
  Susana Carvalheira, Miguel Oliveira, Margarita Robaina, João C. O. Matias *(online)*
- CHARACTERIZATION OF THE ECONOMIC, ENVIRONMENTAL, AND SOCIAL IMPACTS OF RENEWABLE ENERGIES Edimar Ramalho; Max López-Maciel; Mara Madaleno; José Villar; Marta Ferreira Dias; Anabela Botelho; Margarita Robaina *(presencial)*
- RENEWABLE ENERGY COMMUNITIES: CONCEPTS, APPROACHES AND THE CASE STUDY OF TELHEIRAS NEIGHBORHOOD IN LISBON
  Evandro Ferreira, João Pedro Gouveia, Miguel Macias Sequeira *(online)*
- CONSUMERS SWITCHING INTENTION AMONG ELECTRICITY SUPPLIERS: A PUSH-PULL-MOORING MODEL
  Fábio Vieira, Mónica Meireles, Graça Trindade *(online)*

B- Energy Poverty *(online)*

Chair: Mara Madaleno

link: https://videoconf-colibri.zoom.us/j/94079183124?pwd=Q00zWU0xYk5WY25vQW53OTMrK1JLZz09
room: 10.1.16

- AN ASSESMENT OF FUEL POVERTY IN TROPICAL TERRITORY: CASE OF LA REUNION
  Manitra Rakotomena, Olivia Ricci
- ANALYSIS OF FINANCING SCHEMES TARGETING ENERGY EFFICIENCY AND ENERGY POVERTY MITIGATION IN THE EUROPEAN UNION, UK, AUSTRALIA AND NEW ZEALAND
  Bárbara Fernandes, João Pedro Gouveia
- EXPLORING ENERGY POVERTY AND THERMAL COMFORT IN UPPER SECONDARY STUDENTS: A CASE STUDY OF LISBON, PORTUGAL
  Inês Valente, João Pedro Gouveia
- STUDENTS' PERCEPTION OF ENERGY POVERTY— COMPARATIVE ANALYSIS AMONG CITIES IN DIFFERENT COUNTRIES AND AMONG REGIONS IN PORTUGAL
  Carolina Cruz Castro, João Pedro Gouveia
- PORTUGUESE DWELLINGS ACCESS TO MOBILITY IN AN EVERGROWING ENERGY VULNERABLE REALITY
  João Bodião, João Pedro Gouveia
- ENERGY POVERTY ADVISORY HUB: SUPPORTING ENERGY POVERTY DIAGNOSIS THROUGH INDICATORS SELECTION, Salomé Bessa, João Pedro Gouveia, Pedro Palma, Katherine Mahoney, Miguel Sequeira

12h15 – 13h15: Round Table

Economic Relevance in Environmental and Energy problems solutions

link: https://videoconf-colibri.zoom.us/j/94079183124?pwd=Q00zWU0xYk5WY25vQW53OTMrK1JLZz09
room: 10.2.2

João Matias (GOVCOPP, DEGEIT, UA) -Project BioAgroFlores https://BioAgroFlores.web.ua.pt

Luís Tarelho (CESAM, DAO, UA) – Project Biovalchar https://biovalchar.web.ua.pt/

Margarita Robaina (GOVCOPP. DEGEIT, UA) – Project R3EA r3ea (ua.pt)

Closing and announce of the best presentation by Master or PhD student (awarded by the Portuguese Association of Energy Economics - APEEN).

Keynote Speakers & Round Table

10h00 – 10h45: Keynote Speaker:

João Pedro Gouveia (Firefly, CENSE, FCT-NOVA)

EXPLORING ENERGY POVERTY AT MULTIPLE SCALES: POLICIES, RESEARCH AND ON THE GROUND ACTION

Chair: Marta Ferreira Dias
link: https://videoconf-colibri.zoom.us/j/94079183124?pwd=Q00zWU0xYk5WY25vQW53OTMrK1JLZz09; room: 10.2.2

João Pedro Gouveia Short Bio:

He holds a PhD in Climate Change and Sustainable Development Policies. He is director of the Firefly laboratory and senior researcher at the Center for Environmental and Sustainability Research (CENSE), where he leads research on energy efficiency in buildings, energy poverty, mitigation and adaptation to climate change. He is also a visiting professor at FCT - Universidade NOVA de Lisboa and at ISEC Lisboa. João Pedro is part of the Coordination team of EPAH - EU Energy Poverty Advisory Hub of the European Commission.

12h15 – 13h15: Round Table

Economic Relevance in Environmental and Energy problems solutions

link: https://videoconf-colibri.zoom.us/j/94079183124?pwd=Q00zWU0xYk5WY25vQW53OTMrK1JLZz09
room: 10.2.2

João Matias (GOVCOPP, DEGEIT, UA) –

Project BioAgroFlores https://BioAgroFlores.web.ua.pt

BioAgroFloRes

The objective of BioAgroFloRes is to propose solutions that encourage the valorization of residual agro-forestry biomass (BAFR) in the production of thermal/electric energy or as raw material for other industries (eg pellet or fertilizer industries).

Thus, a functional prototype of an intelligent web platform designated by W@BioAgroFloRes will be developed, which assists stakeholders involved in biomass CA in two relevant real problems:

1. How to stimulate and bring BAFR's supply and demand closer together? The BioAgroFloRes solution will include a biomass market to link supply and demand, helping small farmers and landowners and public and private entities to find a final destination for their BAFR, supporting them in the process of making raw materials available, through the permanent updating of information in real time;

2. How to configure and plan BAFR's CA over a given time horizon (e.g. deciding modes of transport to use, distribution alternatives and determining the ideal location for different types of facilities)?

BioAgroFloRes also intends to contribute to the achievement of several EU strategic and structural objectives, including those related to job creation, fire prevention and surveillance, circular economy with resource efficiency, consumption of renewable energy and innovation for a green infrastructure. BioAgroFloRes aims to help Portugal formulate a more coherent strategy for the BAFR, reducing the fuel loads that fuel fires that are difficult to control.

Luís Tarelho (CESAM, DAO, UA) –

Project Biovalchar https://biovalchar.web.ua.pt/

Forest clearing operations are the first line of fire prevention. However, these operations generate large amounts of residual forest biomass (BFR) that cannot legally be left in the field, requiring proper management.

The BFR includes highly flammable vegetation such as gorse, broom and invasive species such as acacias, whose proliferation and accumulation promotes the occurrence of forest fires. In addition to the negative impacts on the rural and forestry economy, fires are also a vector of desertification and degradation of soil quality.

To promote the valorization of BFR in rural areas in appropriate models of forest management, it is necessary to develop alternative uses that add economic and environmental benefits by reducing the fuel load.

Since the composition of this biomass does not make it suitable for thermochemical conversion processes (e.g. combustion) for energy production due to ash encrustation problems, the production of biochar by pyrolysis of residual forest biomass is an alternative with the potential to generate added value products (soil additives). In addition, guaranteeing the energy sustainability of the process and minimizing the environmental impacts associated with the emission of gaseous pollutants are aspects of great importance.

The BioValChar project seeks to respond to the challenges related to the valorization of low quality BFR through the production of biochar by pyrolysis – energetically and environmentally sustainable – which can then be applied to forest and rural soils to increase the stock of nutrients and agro-forestry productivity, thus reducing the need for fertilizers, with associated economic advantages.

This approach will allow carbon and nutrients to be recycled and create synergies between forest management, fire prevention, soil quality improvement and rural development, under the Circular Economy principle.

Margarita Robaina (GOVCOPP. DEGEIT, UA) –

Project R3EA r3ea (ua.pt)

Energias Renováveis
Avaliação económica e de externalidades

Objectives - The project is structured in two phases:

First phase: Evaluate the impact of new investments in solar and wind electricity generation capacity on the emission of greenhouse gases (GHG) and other toxic gases for the Central Region of Portugal, using a centralized planning model, based on operating and investment costs. The recent objectives of the Portuguese National Energy and Climate Plan (PNEC) will be considered. This region was chosen because of its relevance in the national energy sector and its potential to make a positive contribution to Europe's energy efficiency and RE commitments. Namely, 70% of its final electricity consumption is based on renewable generation, while the national average is 59.1%.

Second phase: Evaluate the local effects of the most relevant externalities, such as the reduction of emissions, electricity prices, energy dependency, the creation of new business models (such as RE communities), job creation, among others. Negative impacts (eg visual pollution) will also be considered. and energy, the creation of new business models such as RE communities, job creation).

Abstracts of the Scientific Parallel Sessions

Scientific Parallel Sessions 1:

A- Energy Innovation *(online)*

Chair: Mara Madaleno
link: https://videoconf-colibri.zoom.us/j/94079183124?pwd=Q00zWU0xYk5WY25vQW53OTMrK1JLZz09
room: 10.1.16

- USING ARTIFICIAL INTELLIGENCE TO CREATE A RENEWABLE ENERGY SENTIMENT INDEX FOR AUSTRALIA
  Xi Li, Stefan Trück
- AN ANALYSIS OF PRICE-SETTING GENERATION TECHNOLOGIES IN THE AUSTRALIAN NATIONAL ELECTRICITY MARKET
  Santosh Sapkota, Lin Han, Stefan Trück
- EXPLAINABLE ARTIFICIAL INTELLIGENCE (XAI) FOR ENERGY POVERTY ANALYSIS: A SPANISH CASE OF STUDY
  Miguel Angel Rios, Ignacio Segarra Tamarit, Roberto Barrella
- PERFORMANCE OF GREEN AND CONVENTIONAL FUNDS: EVIDENCE FOR PORTUGUESE FUNDS
  Elisabete Neves, Diana Santos
- NON-RESIDENTIAL HARD-TO-REACH ENERGY USERS: A VAST AUDIENCE FORGOTTEN BY THE ENERGY TRANSITION?
  Miguel Macias Sequeira, João Pedro Gouveia

B- Energy Transition *(hybrid)*

Chair: Margarita Robaina
link: https://videoconf-colibri.zoom.us/j/91547292878 room: 10.2.2

- ASSESSING THE LITERATURE ON ENERGY TRANSITION AND ECONOMICS IN LATIN AMERICA: AN IMPACT AND CENTRALITY ANALYSIS
  Vitor Benfica, António Cardoso Marques *(presencial)*
- CONSEQUENCES OF THE ENERGY TRANSITION ON POVERTY AND DEPENDENCE IN COUNTRIES IN THE SADC REGION: AN ANALYSIS OF PANEL DATA FROM 2000-2021
  Querubim Capimolo Lucamba, António Cardoso Marques, Diogo André Pereira *(presencial)*
- EXPLORING PERCEPTIONS OF COMPETING AGENDAS IN PORTUGUESE CARBON NEUTRALITY POLICIES
  Katherine Mahoney, João Pedro Gouveia, Rita Lopes, Siddharth Sareen *(online)*
- ASSESSING THE ECONOMIC IMPACTS OF THE CHILEAN ENERGY TRANSITION: AN INPUT-OUTPUT HYBRID EQUILIBRIUM MODEL, Tomás Ochoa, Diego Vera, Esteban Gil, George Kerrigan, Víctor Hinojosa *(online)*
- RENEWABLE ENERGIES INVESTMENT IN EUROPEAN COUNTRIES – THE CASE OF PORTUGAL (SOLAR AND WIND)
  Max López-Maciel, Edimar Ramalho, Mara Madaleno, José Villar, André de Oliveira, Marta Ferreira Dias, Anabela Botelho, Margarita Robaina *(presencial)*

USING ARTIFICIAL INTELLIGENCE TO CREATE A RENEWABLE ENERGY SENTIMENT INDEX FOR AUSTRALIA

Xi Li[1], Stefan Trück[2]

[1]Macquarie Business School, Sydney, Australia, xili14@students.mq.edu.au
[2]Macquarie Business School, Sydney, Australia, stefan.trueck@mq.edu.au

Extended Abstract

This study develops a renewable energy sentiment index for Australia to examine public perception and dynamic changes in attitudes towards renewable energy. Australia is currently undertaking a transitioning to a significantly higher share of renewable energy to address climate change, enhance energy sustainability, and fulfil the Paris Agreement pledge. Over the last decade, deployment of renewable energy has increased significantly, in part generation from solar and wind.

The sentiment index is created based on examining tweets of the Australian public with regards to renewable energy. Social media, particularly Twitter, provides individuals with a platform to share and express their emotions, opinions, and thoughts on a wide range of topics, including personal experiences, social issues, and political events. To evaluate the effectiveness of various sentiment analysis approaches, we utilize Plutchik's three-dimensional circumplex model (Plutchik, 2001) to identify changes in social tone. In addition, the study will compare the performance of three lexicon-based methods with an artificial intelligence-based classification, namely ChatGPT. Through this comparison, the study aims to evaluate the effectiveness of different approaches in sentiment analysis.

We employ business analytics techniques such as web crawling, text mining, sentiment analysis, and data mining to measure and analyze the opinions, emotions and sentiments expressed in written documents related to renewable energy. By doing so, this investigation will provide insights into the factors that shape public perception of renewable energy and the effectiveness of various sentiment analysis approaches. Our analysis allows us to investigate the underlying patterns and trends that shape public discourse surrounding renewable energy, ultimately offering valuable insights for policymakers and stakeholders in the renewable energy sector. The objectives of this study are to: (i) compare the effectiveness of three lexicon-based methods with ChatGPT to develop a more accurate sentiment analysis model that incorporates machine learning principles and time series analysis to account for specific events that impact renewable energy; (ii) investigate public perceptions of such events as the Russian-Ukraine conflict, emerging energy crisis, and substantial increase in electricity prices through specially designed coding and classification methods; and (iii) create a renewable energy sentiment index for Australia.

ChatGPT, created by OpenAI, is a cutting-edge natural language processing model that has attracted significant attention from researchers and the wider audience. In this study, we focus on the application of ChatGPT in sentiment analysis, specifically analyzing emotions and sentiment polarity in tweets. This paper is unique in its examination of the performance of lexicon-based approaches, including the National Research Council of Canada (NRC) (Mohammad & Turney, 2013), Bing Liu Opinion Lexicon (Liu, 2012),

and Textblob (Juantita et al., 2022). We compare these methodologies with ChatGPT to evaluate their effectiveness in extracting sentiment information from social media content, providing valuable insights into the capabilities and potential applications of ChatGPT in sentiment analysis.

Using 23 keywords related to renewable energy to collect tweets, we explore the reliability of sentiment polarity classifications (‘negative’, ‘neutral’, ‘positive’) as well as changes in sentiment towards renewable energy in Australia between 2021 and 2023. In particular, we distinguish between the period before and after the outbreak of the Russia-Ukraine war.

Examining the classification results of the different techniques with regards to inter-rater-reliability, we find Krippendorff's Alpha to be less than 0.2, indicating low inter-rater reliability, which suggests that the four methods yield very different results. We find that ChatGPT provides a significantly higher agreement with human-based polarity classification of the tweets, while the three lexicon-based approaches typically fail to provide a correct classification with regards to polarity. Overall, our findings suggest that artificial intelligence-based methods such as ChatGPT seem to provide results superior to those of lexicon-based sentiment classification approaches. Furthermore, our results reveal that the level of joy expressed in renewable energy tweets decreases from 59.5% to 54.1% between the two time periods. Moreover, there is an increase in the level of anger expressed in tweets, from 34.8% to 40.1%, following the Russian attack on Ukraine. Thus, our findings suggest that overall sentiment expressed on Twitter regarding renewable energy in Australia has become less positive and more negative after the war in Ukraine. It is important to note that the study did not investigate the causes behind the observed changes in sentiment. Nonetheless, our findings highlight the need to monitor changes in public sentiment towards renewable energy and to identify potential factors that could contribute to shifts in sentiment.

The study is significant in that it provides new and important insight on measuring public opinion and sentiment towards renewable energy, using artificial intelligence tools. Furthermore, we argue that better understanding the public perception of renewable energy is valuable for policymakers and stakeholders in the energy industry. Therefore, the creation of a suitable renewable energy sentiment index will help to inform decision-making, particularly as the world moves towards a more sustainable future.

REFERENCES

Chapman, A., Shigetomi, Y., Ohno, H., McLellan, B., Shinozaki, A. (2021). Evaluating the global impact of low-carbon energy transitions on social equity. *Environmental Innovation and Societal Transitions,* 40.

Juanita, S., Adiyarta, K., and Syafrullah, M. (2022). Sentiment analysis on E-Marketplace user opinions using lexicon-based and Naïve Bayes model*, Computer Science and Informatics (EECSI)*.

Kim, S. Y., Ganesan, K., Dickens, P., and Panda, S. (2021). Public sentiment toward solar energy - Opinion mining of twitter using a transformer-based language model. *Sustainability*, 13(5).

Liu, B. (2012). Sentiment analysis and opinion mining. *Synthesis Lectures on Human Language Technologies*, 5(1), 1–167.

Mohammad, S.M., and Turney, P.D. (2010). Emotions evoked by common words and phrases: Using mechanical turk to create an emotion lexicon, *Association for Computational Linguistics*, 26-34

Najim, S. and Matsumoto, K. (2020) Does renewable energy substitute LNG international trade in the energy transition? (2020). *Energy Economics*, 92.

Plutchik, R. (2001). The nature of emotions. American Scientist, 89(4).

Tumarkin, R., and Whitelaw, R. F. (2001). News or Noise? Internet Postings and Stock Prices. Financial Analysts Journal, 57(3), 41–51.

Wolsink, M. (2012). The research agenda on social acceptance of distributed generation in smart grids: Renewable as common pool resources. Renewable and Sustainable Energy Reviews, 16(1).

AN ANALYSIS OF PRICE-SETTING GENERATION TECHNOLOGIES IN THE AUSTRALIAN NATIONAL ELECTRICITY MARKET

Santosh Sapkota[1], Lin Han[2], Stefan Trück[3]

[1]*Macquarie Business School, Sydney, Australia, santosh.sapkota1@students.mq.edu.au*
[2]*Macquarie Business School, Sydney, Australia, lin.han@mq.edu.au*
[2]*Macquarie Business School, Sydney, Australia, stefan.trueck@mq.edu.au*

Extended Abstract

This study examines price-setting generation technologies in the Australian National Electricity Market (NEM). An electricity generator is considered as the price-setting or marginal one when, during a specific period, all the capacity of the low-cost generators has been utilized, and this generator is the cheapest available option to meet the remaining demand. As wholesale electricity prices at an exchange are determined by the short-run marginal cost of these generators, marginal generators play a crucial role in the decision-making process of all the stakeholders of electricity exchanges. Being the most competitive energy source in terms of the levelized cost of electricity and supported by government policies to reduce carbon emissions, variable renewable energy (VRE) penetration is increasing globally, including in the NEM. This study examines the impact of this change on price-setting technologies in the NEM to contribute to the literature on this topic. In particular, we focus on the structure and dynamic changes in price-setting technologies across regional markets in the NEM.

Despite the important role price-setting plays in wholesale electricity markets, very little research has been conducted on the analysis of price-setting technologies. Furthermore, prior studies on this topic have typically relied on proxy or model-based approaches, see, e.g., Blume-Werry et al. (2018), Germeshausen and Wölfing (2020), Härtel and Korpa (2021), Zakeri et al. (2022). In contrast, our study provides a more comprehensive understanding of price-setting dynamics by using high-frequency empirical data. Our analysis of 5-minute dispatch data, spanning a relatively long sample period from 2009-2022, is the first to delve into such precise and extensive data on this topic. This detailed analysis has enabled us to gain a nuanced understanding of how price-setting technologies behave and how they impact electricity dynamics. Additionally, while prior research has primarily focused on price-setting technologies within the electricity market, our study takes a broader approach, investigating how these technologies evolve over time as well as examining factors that drive these changes.

Our analysis starts with a static analysis to investigate the factors influencing price-setting technologies in the NEM. Our findings reveal that considering the entire study period, black coal generators typically dominate the price-setting process. While hydropower, gas, and brown coal generators also play a role in setting electricity prices for significant periods, the contribution of renewable generators, such as solar and wind, remains negligible.

Furthermore, we discover an inverse relationship between the price-setting share of coal generators and demand. As demand increases, the share of coal generators in setting electricity prices decreases, and vice versa. In contrast, hydropower and gas generators tend to be more active in setting prices with increasing demand. In terms of price levels, our research revealed that wind and solar generators tend to be more active in setting electricity prices at lower levels. Black coal generators are more active in setting prices at mid-price levels, while hydropower and gas tend to set prices at higher levels.

In a second step, we expand our analysis to a dynamic environment to analyze the changing share of generators in price setting over time and under various circumstances. Using rolling-window approach, we observe that the share of black coal generators in setting electricity prices has been decreasing over time, while the share of hydropower and gas generators as price-setters has increased. Additionally, we found that the share of renewable generators, specifically solar and wind, as price-setters has accelerated since 2018, while battery storage technologies have had minimal impact on price setting.

Our regression analysis results show that, except for the first lower demand decile, the share of black coal generators in setting electricity prices is decreasing across all demand deciles. On the other hand, the share of renewable generators and gas generators has been increasing across all demand deciles. We also observe that the trend in the share of price setting across different price deciles is not consistent with demand deciles. While the share of black coal generators in setting electricity prices was decreasing in the lower and upper price deciles, it was increasing in the middle price deciles. In contrast, the share of hydropower generators in setting prices was decreasing in the middle price deciles but increasing in the lower and upper price deciles. The share of gas generators in price setting has been decreasing in lower price deciles, while it has been increasing in higher price deciles. The share of wind and solar generators in price setting has been increasing across all price deciles.

Our findings suggest that being "dispatchable" and "flexible" is likely to be even more rewarded in the future. The ongoing withdrawal of baseload generators is expected to increase the market power of flexible generators. The increase in renewable generators will results in greater intermittency in electricity production, which will further enhance the price-setting capability of such flexible generators. The price-setting share of renewable generators (such as solar and wind) is significantly lower than their market share which indicates that these generators are often inframarginal, allowing them to earn economic rent. This indicates that further investment in renewable electricity has the potential to be rewarding if this situation persists. Interestingly, even with the shut-down of coal generators in the South Australian market, they continue to significantly influence electricity prices in the region. This is evidence of the strong influence of neighbouring markets in setting electricity prices.

References

Blume-Werry, Eike and Faber, Thomas and Hirth, Lion and Huber, Claus and Everts, Martin, Eyes on the Price: Which Power Generation Technologies Set the Market Price? Price Setting in European Electricity Markets: An Application to the Proposed Dutch Carbon Price Floor (January 10, 2019). FEEM Working Paper No. 34.2018.

Germeshausen, R., & Wölfing, N. (2020). How marginal is lignite? Two simple approaches to determine price-setting technologies in power markets. *Energy Policy* 142.

Zakeri, B., Staffell, I., Dodds, P., Grubb, M., Ekins, P., Jääskeläinen, J., Cross S., Helin, K., Castagneto-Gissey. G., (2022). Energy Transitons in Europe – Role of Natural Gas in Electricity Prices. Working Paper.

Härtel, P., and Korpas, M. (2021). Demystifying market clearing and price setting effects in low-carbon energy systems. *Energy Economics* 93.

EXPLAINABLE ARTIFICIAL INTELLIGENCE (XAI) FOR ENERGY POVERTY ANALYSIS: A SPANISH CASE OF STUDY

Miguel Angel Rios[1,2], Ignacio Segarra Tamarit[1], Roberto Barrella[1,2]

[1]*Institute for Research in Technology IIT - Comillas Pontifical University, Spain.*
[2]*Chair of Energy and Poverty - Comillas Pontifical University, Spain.*
marios@comillas.edu, isegarra@comillas.edu, rbarrella@comillas.edu

Extended Abstract

Keywords: [Energy Poverty, Explainable Artificial intelligence, Indicators, Machine Learning, Vulnerable consumers, Energy Efficiency].

1 PROBLEM DEFINITION

The transition to a low-carbon and sustainable energy system is becoming increasingly urgent to address the global climate crisis and achieve sustainable development goals. However, this transition can create or exacerbate inequalities and social exclusion based on the energy system if not designed and implemented equitably (Dwarkasing 2023). One way to highlight social inequalities and household vulnerabilities is to include energy poverty as an energy justice dimension for the energy transition pathways. To mitigate its effects, targeted energy policies that are precisely tailored to the needs of different types of consumers to improve their quality of life, reduce inequality gaps and fight energy poverty need to be considered. Energy poverty can be broadly understood as an issue related to the affordability of energy households require to meet their essential energy needs ensuring a dignified standard of living, which is usually rooted in economic factors such as low income and high energy expenditure but also has a component of low energy efficiency at home level (Moore 2012). To provide a better understanding of the variety of approaches to measure energy poverty, one way to classify indicators is to distinguish them into two main categories: objective and subjective. Objective indicators rely on quantitative data obtained from households, while, on the other hand, subjective indicators are focused on qualitative, individual perceptions collected through interviews (Siksnelyte-Butkiene et al. 2021). Then, considering the second category, a question arises: Can targeted energy policies based on qualitative data be proposed for mitigating energy poverty? Addressing the right seeds of energy poverty and answering this question in different contexts is tricky, and many proposals based on costly measures might not effectively contribute to a structural solution to the problem in the medium-long term (Barrella et al. 2021). In this study, we use Explainable Artificial Intelligence (XAI) using a model based on the Gradient Boosting approach that allows us to study the energy problem and shed light on proposing targeted energy policies to deal with energy poverty structurally.

2 UNDERSTANDING ENERGY POVERTY USING XAI

The evolution of computing technology and the amount of data available has driven a leap in data science that also had an impact on many fields. Machine learning techniques are more flexible than classical approaches so they can perform better on nonlinear problems, which can be the case in Energy Poverty. In this paper we combine large datasets, that study the demographics of the Spanish population and The EU statistics on income and living conditions (EU-SILC), with a model based on the Gradient Boosting approach (Chen et al. 2015). This model is, for most hyperparameters, a complex model which, in addition to large amounts of data, can fit complex dynamics, such as those of our problem. Once the model is calibrated, we can proceed to study the Energy Poverty problem by unboxing the black box model of gradient boosting.

We have used gradient boosting for two main reasons. First, it is a ML model that tends to present extremely good performances in real-life problems. Secondly, XAI is more developed for this kind of algorithm than for other high complexity algorithms (e.g. Neural Networks). Furthermore, the SHapley Additive exPlanations (SHAP) can be computed in polynomial time (Lundberg et al. 2020). The utilisation of SHAP is very hot in ML the state of the art right now as it provides high interpretability to complex real-life problems. In this paper SHAP values are used in order to quantify the impact of different variables and indexes to the Energy Poverty via the complex model proposed in the previous section. The preliminary results obtained are further explained in the following section.

3 PRELIMINARY RESULTS AND POTENTIALITIES OF THE PROPOSAL

With the previous methodology we obtain two main tools. First, a sophisticated model that is capable of identifying individuals that may be at risk of Energy Poverty given certain indicators. Second, we can understand the impact of the factors for the population depending on their characteristics, this allows to develop policies that target mitigating those poverty factors. Nevertheless, the explained analysis assumes that the population is heterogeneous. This assumption is debatable. For example, a median income household may be in in risk of Energy Poverty because they live in a building that, energetically, is inefficient while a low income household Energy Poverty may be more related to lack of economic means to purchase energy. For this reason, it is important to study the factors that induce Energy Poverty in different segments of the population. We cluster the data based on their income and study each group individually detecting the factors that induce Energy Poverty among those groups and propose targeted policies for them.

REFERENCES

Barrella, Roberto, José Ignacio Linares, José Carlos Romero, Eva Arenas, and Efraim Centeno. 2021. ‘Does Cash Money Solve Energy Poverty? Assessing the Impact of Household Heating Allowances in Spain’. *Energy Research & Social Science* 80:102216. doi: 10.1016/j.erss.2021.102216.

Chen, Tianqi, Tong He, Michael Benesty, Vadim Khotilovich, Yuan Tang, Hyunsu Cho, Kailong Chen, Rory Mitchell, Ignacio Cano, and Tianyi Zhou. 2015. ‘Xgboost: Extreme Gradient Boosting’. *R Package Version 0.4-2* 1(4):1–4.

Dwarkasing, Chandni. 2023. ‘Inequality Determined Social Outcomes of Low-Carbon Transition Policies: A Conceptual Meta-Review of Justice Impacts’. *Energy Research & Social Science* 97:102974. doi: 10.1016/j.erss.2023.102974.

Lundberg, Scott M., Gabriel Erion, Hugh Chen, Alex DeGrave, Jordan M. Prutkin, Bala Nair, Ronit Katz, Jonathan Himmelfarb, Nisha Bansal, and Su-In Lee. 2020. ‘From Local Explanations to Global Understanding with Explainable AI for Trees’. *Nature Machine Intelligence* 2(1):56–67. doi: 10.1038/s42256-019-0138-9.

Moore, Richard. 2012. ‘Definitions of Fuel Poverty: Implications for Policy’. *Energy Policy* 49:19–26. doi: 10.1016/j.enpol.2012.01.057.

Siksnelyte-Butkiene, Indre, Dalia Streimikiene, Vidas Lekavicius, and Tomas Balezentis. 2021. ‘Energy Poverty Indicators: A Systematic Literature Review and Comprehensive Analysis of Integrity’. *Sustainable Cities and Society* 67:102756. doi: 10.1016/j.scs.2021.102756.

PERFORMANCE OF GREEN AND CONVENTIONAL FUNDS: EVIDENCE FOR PORTUGUESE FUNDS

Elisabete Neves[1], Diana Santos[2]

[1] *Polytechnic of Coimbra, Coimbra Business School|ISCAC, Coimbra Portugal & UTAD|CETRAD, mneves@iscac.pt*

[2]Polytechnic of Coimbra, Coimbra Business School|ISCAC*, dianacaniaux@gmail.com*

Abstract

This paper aims to analyze whether the factors that explain the performance of sustainable investment funds in Portugal are the same as those that explain the performance of conventional funds. To achieve this aim, we have used a sample of 31 sustainable and 27 conventional funds actively managed in Portugal from 2017 to 2021 was analyzed. To test the hypotheses formulated according to the proposed literature review, the panel data methodology was used, specifically the Generalized Method of Moments (GMM) system estimation method proposed by Arellano and Bond (1991) and improved by Arellano and Bover (1995) and Blundell and Bond (1998). The results display that there are no significant differences in the determinants of both types of funds, except for the liquidity variable which, having a negative relationship with the performance of sustainable funds, may suggest that liquidity restrictions help to manage the fund with a vision long-term, enabling the implementation of strategies that lead to better performance. In none of the types of funds considered, the presence of women as fund managers are fundamental in explaining performance, which reinforces the idea that it will be specific knowledge and skills and not gender that is of interest in performance evaluation.
As far as the authors are aware, this is the first study to consider the classification assigned by the Sustainable Finance Disclosure Regulation as a measure of sustainability.

Keywords: Green vs conventional Portuguese funds; GMM system.

1. Introduction

Sustainable development is essential for the world's ecological well-being and requires the execution of economic and business strategies that respect the environment (Ji, Chen, Mirza and Umar, 2021).
The Sustainable Development Goals (SDGs) are part of the 2030 Agenda adopted by all Member States of the United Nations in 2015, which defines the priorities and aspirations of global sustainable development for 2030. They are a set of 17 goals that recognize that eradicating poverty and other deprivations must be accompanied by strategies that improve health and education, reduce inequality, and stimulate economic growth, while combating climate change and preserving ecosystems.
Both the public and private sectors are needed to accelerate the transition to a sustainable economy and achieve these overall goals. In this context, investors have an important role in promoting the reorientation of financial markets to support these objectives (Miralles-Quirós, Miralles-Quirós and Nogueira, 2020). Investors may be motivated to incorporate environmental, social and corporate governance (ESG) criteria into the investment process with the expectation that sustainable investing will increase returns (Hartzmark and Sussman, 2019), but also because they are willing to forgo the financial performance to invest according to their social preferences (Riedl and Smeets, 2017).
According to the Global Sustainable Investment Alliance (2020), at the beginning of 2020 sustainable investment in the main financial markets reached US$ 35.3 trillion, an increase of 15% compared to 2018. Recent studies have analyzed the performance of sustainable funds considering various sustainability measures, namely through Social Responsible Investment - SRI (El Ghoul, Karoui, Patel and Ramani, 2023; Klinkowska and Zhao, 2023; Saci , Jasimuddin and Hasan, 2022), green funds (Chen, Weber, Song and Li, 2023; Gonçalves, Pimentel and Gaio, 2021), adherence to the United Nations Principles for Responsible Investment (PR) (Kim and Yoon, 2022) and also through mutual funds that call themselves ESG (Raghunandan and Rajgopal, 2022).

However, the lack of a universal standard for ESG reporting potentially fuels phenomena of greenwashing (Toscano, Balzarotti and Re, 2022), a strategy whereby companies seek to gain or maintain legitimacy by disproportionately disclosing beneficial or relatively benign performance indicators to obscure its less impressive overall performance (Marquis, Toffel, and Zhou, 2016).
To ensure greater transparency in terms of the financial markets' environmental and social responsibilities, on March 10, 2021, the Sustainable Finance Disclosure Regulation (SFDR) published within the scope of the Sustainable Finance European Commission Sustainable Finance Action. This regulation requires the disclosure of specific information by asset managers and investment advisers regarding the integration of sustainability risks and the consideration of negative impacts to sustainability in their processes, and the provision of information related to the sustainability in relation to financial products.
The SFDR classifies financial products into 3 categories (Article 6, Article 8 and Article 9) according to the degree to which they consider sustainability. Article 9 products have as their main objective sustainable investment, that is, investment in an economic activity that contributes to an environmental or social objective, and provided that such investment does not significantly harm any other environmental or social objective and that the target companies of the investment follow good governance practices. Article 8 products promote environmental and/or social characteristics and can invest in sustainable investments, but the main objective is not to invest in sustainability. Article 6 products integrate ESG considerations into the process of making an investment decision, or explain why sustainability risk is not material, but do not meet the complementary criteria of Article 8 or Article 9 strategies.
In this context, this study aims to analyze whether the factors that explain the performance of sustainable investment funds in Portugal are the same as those that explain the performance of conventional funds. To achieve this objective, the Sharpe Index was used as a performance measure. The study focuses on a sample of 31 sustainable funds and 27 conventional funds actively managed in Portugal, in the period between 2017 and 2021. This study contributes to the existing literature on mutual funds in Portugal, namely regarding funds that have environmental and social concerns. Furthermore, as far as the authors are aware, this is the first study to consider the classification assigned by the Sustainable Finance Disclosure Regulation as a measure of sustainability.
As sustainability is such an important and current topic, this work may have important practical implications both for fund managers and management companies of undertakings for collective investment, allowing them to make better decisions, and for potential investors who consider sustainability a preponderant factor in the selection of your investments, since it provides useful information about the factors that influence the performance of sustainable funds. Finally, academics may also find this study a foundation for future research.

2. Literature Review

2.1 Expense ratio

Kiymaz (2015); Tauni, Iqbal and Umar (2017) and Nguyen, Shahid and Kernohan (2018) showed a positive relationship between expense ratio and fund performance, suggesting that in funds that perform better, fund management tends to charge more for its work management. In turn, Vidal-García, Vidal, Boubaker and Hassan (2018) when studying a sample of 16085 mutual funds domiciled in 35 countries, obtained two different results. The empirical results of the DEA model show a statistically significant positive relationship between fund expenses and risk-adjusted performance. On the other hand, the results of the regression model show a negative relationship between expenses and risk-adjusted performance, suggesting that higher expenses lead to worse performance. This statistically significant negative relationship was also demonstrated by Singh and Tandon (2022) in a sample of 81 Indian equity mutual funds and by Mamatzakis and Tsionas (2020) in a sample of 10391 US mutual funds. Still along these lines, Graham, Lassala and Navarrete (2020) concluded that funds with low management fees and low continuous fees have attractive Sharpe ratios and high returns. Accordingly, the following hypothesis is considered (with no predicted signal):
H1: Fund's expense ratio influences its performance.

2.2 Age

Neves, Gouveia and Vergos (2023), Nguyen, Shahid and Kernohan (2018) demonstrate that fund age has a positive relationship with fund performance, in line with Kiymaz (2015).
On the other hand, authors such as Hensawang (2022), Malaquias and Junior (2019), Pástor, Stambaugh and Taylor (2015), Singh and Tandon (2022), and Stafylas, Anderson and Uddin (2016) found a significant negative relationship between age and performance of the fund. Younger funds perform better because they tend to be more flexible in developing strategies to survive in the market (Stafylas, Anderson and

Uddin, 2016), or greater mastery of new technology (Pástor, Stambaugh and Taylor, 2015) intending to overcome the market (Malachi and Junior, 2019).
Accordingly, the following hypothesis is considered (with no predicted signal):
H2: The fund age influences its performance.

2.3 Size

Ferreira, Keswani, Miguel and Ramos (2013), Malaquias and Junior (2019), Otero-González, Santomil and Correia-Domingues (2019), and Tuzcu and Ertugay (2020) demonstrate that size has a positive relationship with performance. The fund size is correlated with the fund's gross value, and, in principle, the fund manager takes advantage of synergies. Ferreira, Keswani, Miguel and Ramos (2013) suggest that in the sample of non-US funds, larger funds perform better as they benefit from substantial savings in trading fees and lending fees.
Ding, Zheng and Zhu (2015) found evidence of a U-shaped relationship between fund size and performance in a sample of 1640 emerging equity funds from Asia.
On the other hand, authors such as Babalos, Mamatzajis and Matousek (2015), Kiymaz (2015), Nguyen, Shahid and Kernohan (2018) and Zhu (2018) found a negative relationship between fund size and performance. Babalos, Mamatzajis and Matousek (2015) state that larger funds are characterized by reduced flexibility and, therefore, may underperform, especially during periods of market turbulence.
Accordingly, the following hypothesis is proposed (with no predicted signal):
H3: The fund size influences its performance.

2.4 Risk

Gouveia, Neves, Dias and Antunes (2018) consider risk as an important factor to explain the efficiency of Portuguese equity funds.
Andreu, Sarto and Serrano (2019) studied a sample of 144 actively managed Spanish equity funds and their results suggest that funds that increase their risk level perform significantly better than funds that reduce or maintain risk levels. stable risk. Also, Livingston, Yao and Zhou (2019) when studying a sample of US stock mutual funds demonstrate that the superior performance of actively managed funds implies greater risks.
On the other hand, Neves, Gouveia and Vergos (2023) and Vidal-García et al. (2018) observed a negative relationship between fund risk and fund performance, indicating that riskier funds perform worse. Huang, Sialm and Zhang (2011) when studying the consequences of changing risk on the performance of 2335 actively managed stock mutual funds, conclude that funds that increase risk perform worse than funds that maintain stable risk levels over time. of time. The authors suggest that risk shifting may be driven by agency issues. Funds with higher costs may have greater incentives to opportunistically manipulate their earnings.
Accordingly, the following hypothesis is proposed (with no predicted signal)
H4: There is a significant relationship between the fund's risk and its performance.

2.5 Liquidity

Neves, Gouveia and Vergos (2023) show that funds with less liquidity have better efficiency.
Malaquias and Junior (2019) suggest that liquidity restrictions help to manage the fund with a long-term view, enabling the implementation of strategies, such as tax planning, that provide better performance
Makni, Benouda and Delhoumi (2016) when studying a sample of 301 Islamic equity funds suggest that high liquidity has a negative effect on performance.
For Tang, Wang and Xu (2012), larger funds tend to retain most of the portfolios that are not easily bought or sold at an ideal price and, therefore, have low liquidity.
Chen et al. (2004) claim that it may be liquidity constraints that cause fund performance to deteriorate, showing a negative relationship between liquidity and fund performance, following Yan (2008).
On the other hand, Yaqoob, Sun and Khidmat (2017) found a positive relationship between fund liquidity and performance, arguing that more liquid funds are usually traded faster leading to more performance potential.
Therefore, the following hypothesis is considered (with no predicted signal):
H5: Fund liquidity influences its performance.

2.6 Gender

Lin, Yen, and Hsieh (2023) showed that female fund managers tend to achieve higher doubly adjusted alphas than male managers. Likewise, Lu and Teo (2021), in a sample of 38084 hedge funds, concluded that female managers outperform male managers. Bliss and Potter (2002) also demonstrate that US and international stock mutual fund managers tended to obtain higher gross returns than their male counterparts.
Gangi et al. (2020) suggest that through greater female participation in management teams, mutual funds can improve their image as more inclusive organizations that respond to the demands of different stakeholders.

On the other hand, Clare (2017) concluded that female managers tended to underperform in relation to their male colleagues.
Andreu, Sarto and Serrano (2019) suggest that female managers are more risk-averse and less confident than male managers.
Accordingly, the following hypothesis is proposed (with no predicted signal):
H6: The fund manager's gender influences fund performance.

3. Methodology

3.1 Data and Estimation Method

This study is based on a sample of 31 sustainable funds and 27 nationally managed conventional funds during the period 2017 to 2021.
The ranking of funds under the SFDR was obtained from the Morningstar Direct database. As of August 2021, no nationally managed securities funds fall under Article 9 of the SFDR and only 44 fall under Article 8 of the SFDR. Of these 44 funds, 7 are excluded, which are Retirement Savings Funds and 6 funds that did not have information for the totality of years that are intended to be studied using the panel data methodology. That said, the final sample of sustainable funds consists of 31 funds.
The sample of conventional funds corresponds to 27 funds that do not comply with Article 8 of the SFDR, where 18 are open-end securities investment funds with shares and 9 are open-end securities investment funds with bonds.
The gender of the managers was identified based on their first name which was taken from the Morningstar website and the Fundspeople website.
The data relating to the remaining variables were taken from the Report and Accounts available on the website of the Portuguese Securities Market Commission (CMVM) for each fund in each year.
For the calculation of the Sharpe Ratio, the yield on 10-year treasury bonds was used as the risk-free interest rate, whose value is 3.1% for 2017, 1.8% for 2018, 0.8% for 2019, 0.4% for 2020 and 0.3% for 2021.
We have used the Generalized Method of Moments system (GMM) which was initially developed by Arellano and Bond (1991) and improved by Arellano and Bover (1995) and Blundell and Bond (1998). Arellano and Bond (1991) argue that this dynamic model nullifies unobserved effects, despite the existence of omitted variables, enhancing the reliability of the results. In particular, the GMM-System uses instrumental variables with lagged values of the dependent variable, as well as lagged values of independent variables that could suffer from endogeneity (Neves 2018; Vieira et al., 2019). The GMM estimator controls for potential endogeneity, unobserved heterogeneity, and persistence of the dependent variable (García-Herrero, Gavilá and Santabárbara, 2009).

4. Discussion

The Sharpe Ratio both in sustainable funds and in conventional funds, that is, the greater the Prior year's Sharpe Ratio, the higher the current period's Sharpe Ratio. This may suggest that managers recognize that a fund's performance levels must be maintained so that one year's values will have to influence those of another year. The expense ratio is statistically significant ($p<0.01$) in sustainable and conventional funds, corroborating hypothesis 1. This variable is positively related to performance, in line with studies by authors such as Nguyen, Shahid and Kernohan (2018), Rao, Tauni, Iqbal and Umar (2017) or Kiymaz (2015). Funds with a higher expense ratio perform better perhaps because these higher costs support research, marketing and the manager's own specialization. The age of sustainable and conventional funds has a positive relationship with performance, corroborating the study by Kiymaz (2015), or Nguyen, Shahid and Kernohan (2018), suggesting that funds that have been in the market longer accumulate synergies and will be less vulnerable to manipulation of results. As for risk, it is negatively related to performance, suggesting agency problems, which is in line with the results obtained by Huang, Sialm and Zhang (2011) and Vidal-García et al. (2018). The fact that managers have in mind not only financial objectives but also other objectives, such as social and environmental objectives, can weaken incentives to obtain higher risk-adjusted returns and, therefore, increase potential agency costs (Renneboog, Horst e Zhang (2008).

The greater the global net value of the fund, the greater the performance, in line with Ferreira, Keswani, Miguel and Ramos (2013), Malaquias and Junior (2019), Otero-González, Santomil and Correia-Domingues (2019), and Tuzcu and Ertugay (2020), enjoying greater growth opportunities, with the ability to trade spreads and enjoy substantial savings on trading fees. As for liquidity, it is the only variable that has a different relationship with performance in both types of funds. It has a negative relationship with sustainable funds, Malaquias and Junior (2019), Makni, Benouda and Delhoumi (2016). This may suggest that liquidity restrictions help to manage the fund with a long-term vision, enabling the implementation of strategies that lead to better performance. However, it is not significant in conventional funds.

In none of the types of funds considered, the presence of women as fund managers is fundamental in explaining performance, which reinforces the idea that it will be specific knowledge and skills and not gender that is of interest in performance evaluation. Under the umbrella of the Sustainable Development Goals of the 2030 Agenda, now more than ever, it is essential to shift the focus away from gender and place it on the qualification and competence of the manager.

5. Concluding remarks

The main objective of this study was to analyze whether the factors that explain the performance of sustainable investment funds in Portugal are the same as those that explain the performance of conventional funds, using the Sharpe Ratio as a measure of risk-adjusted performance. The study focuses on a sample of 31 sustainable funds and 27 conventional funds actively managed in Portugal, in the period between 2017 and 2021. To test the hypotheses formulated according to the proposed literature review, the panel data methodology was used, specifically the Generalized Method of Moments (GMM) system estimation proposed by Arellano and Bond (1991) and improved by Arellano and Bover (1995) and Blundell and Bond (1998).

Our results emphasize that the determinants of performance in both types of funds are broadly the same, what may be changing is investors' aptitude and awareness of more sustainable funds capable of helping the economy towards a greener commitment and equitable, based on environmental issues and equal working conditions and wages, where skills are the basis and not gender or other fundamentalisms.

The main limitations of this study are the small sample size and the difficulty in obtaining data. This is a time-consuming procedure as the variables are removed manually from the Reports and Accounts of each fund. In addition, the fact that in the analyzed period the sample of sustainable funds is made up only of funds that comply with article 8 of the SFDR, which are those that promote environmental and/or social characteristics and can invest in sustainable investments. , but whose main objective is not to invest in sustainability.

As lines of future research, it would be pertinent to expand the sample, including in sustainable funds those funds that comply with article 9 of the SFDR, that is, which have sustainable investment as their main objective, and expand this study to other countries of the European Union that are subject to to the Sustainable Finance Disclosure Regulation. It would also be interesting to study the years after 2021 in order to understand how asset management companies reacted to the regulation, also introducing the manager's characteristics and knowledge.

The main contributions of this article:

Fund managers can understand the impact of their decisions on risk-adjusted returns and on the perception that the potential investor may have.

Investors realize that sustainable funds can be the future for cleaner and more equitable lives.

Academics and researchers can take advantage of the lines we leave to understand the impact of this new regulation on the return and risk of green funds.

Acknowledgements

This work is supported by national funds, through the FCT – Portuguese Foundation for Science and Technology under the project UIDB/04011/2020

NON-RESIDENTIAL HARD-TO-REACH ENERGY USERS: A VAST AUDIENCE FORGOTTEN BY THE ENERGY TRANSITION?

Miguel Macias Sequeira[1], João Pedro Gouveia[2]

[1]*CENSE – Center for Environmental and Sustainability Research, NOVA School of Science and Technology, NOVA University Lisbon (PORTUGAL), m.sequeira@campus.fct.unl.pt*
[2]*CENSE – Center for Environmental and Sustainability Research, NOVA School of Science and Technology, NOVA University Lisbon (PORTUGAL), jplg@fct.unl.pt*

Abstract

In the context of ongoing energy transitions, the concept of hard-to-reach energy users has been receiving growing attention. Hard-to-reach audiences are usually those who are hard to engage in energy-related interventions, with five major groups mentioned in the literature: vulnerable households, high-income households, tenants and landlords, small and medium enterprises, and commercial subsectors. In this paper, we focus our approach on non-residential hard-to-reach energy users since scarce research has been conducted on these audiences thus far. The specific needs of these vast groups have also been largely neglected by most energy policies and financing schemes. Our approach includes four steps: i) conducting a literature review, ii) proposing a non-residential hard-to-reach framework, iii) selecting a indicator set for the European Union, iv) assessing the size of these audiences in the European Union and its Member States. Key audiences identified included small and medium enterprises and micro-enterprises – characterized by size – and wholesale trade, retail trade, food services, accommodation, offices, and other activities – characterized by subsector of activity. Although data limitations are a key concern, we find that small and medium enterprises and micro-enterprises are vast audiences, comprising 99.8% and 93.5% of all enterprises in the European Union in 2020; while this percentage varies among Member States these groups are very significant. Efforts to more effectively reach these groups should focus on targeted and tailored interventions, including by focusing on the local-scale and by engaging with trusted middle actors. We hope this work sheds a light on traditionally forgotten groups in the European energy transition and that it contributes to the design of energy policies that more effectively reach the hard-to-reach.

Keywords: small and medium enterprises, commercial and services sector, European Union

1. INTRODUCTION

To address the key challenges of climate change and energy poverty, energy transitions are at the top of the agenda. An energy transition as pursued by the European Commission places the active engagement of citizens and businesses at the centre. Against a backdrop of insufficient action, the concept of hard-to-reach (HTR) energy users has been applied to the energy sector and is receiving growing attention both in scientific literature and policy development. The HTR concept has long been used in several areas outside energy, particularly in social services, education, crime prevention, and health. According to Ambrose *et al.* (2019), this concept may be context specific and should not consist of a single list of target groups. This term has its critiques and challenges. While some authors argue that it puts emphasis on policymakers and providers for failing to engage with the HTR, others say it shifts the blame to the individuals (Ambrose *et al.*, 2019).

In the context of the International Energy Agency UsersTCP Task on Hard-To-Reach Energy Users, Rotmann *et al.* (2020) state that "a hard-to-reach energy user is any energy user from the residential & non-residential sectors, who uses any type of energy or fuel, and who is typically either hard-to-reach physically, underserved, or hard-to-engage or motivate in behaviour change, energy efficiency and demand response interventions that are intended to serve our mutual needs". HTR energy users, due to their vulnerabilities, circumstances and/or characteristics, have so far been removed from engaging in the energy transition (Ambrose *et al.*, 2019). They may represent a large percentage of the energy users and their active participation is crucial to achieve climate change mitigation.

Although the HTR definition is purposely broad, five different groups have been highlighted by Ashby *et al*. (2020) and Rotmann *et al.* (2020): i) vulnerable households (including low income and energy poor), ii) high income households, iii) renters and landlords (residential and non-residential), iv) commercial sub-sectors, and v) small and medium enterprises (SMEs). A well-established literature has researched the key barriers across a variety of HTR audiences, underlining competing priorities, financial considerations, mistrust, market failures such as split incentives, and informational barriers (Ashby *et al.*, 2020). In the European Union (EU), these groups may consume a significant share of energy, since they likely represent a relevant share of the residential sector and of the services and commerce sector. Lack of data hinders a more detailed analysis of energy use in HTR groups.

We find that the concept of HTR audiences, as applied to the energy area, is relatively novel, with scarce scientific research conducted under this umbrella, particularly in the EU and for the non-residential sector. Whereas most research on HTR energy users has remained of conceptual and qualitative nature, the novelty of this paper lies in the operationalization of the concept through the systematization of key non-residential profiles, the proposal of an indicator set, and its application to the EU and its Member States. Although our work focuses on the EU, we suggest that the approach can be adapted to other contexts, while being suitable for national and sub-national analysis

This paper is structured as follows. Section 2 summarizes the methods and data selection criteria. Section 3 exposes the existing literature on non-residential HTR audiences while fleshing out the key barriers to their engagement in. Section 4 presents the main results of the work, namely the proposal of a framework for non-residential HTR energy users, the selection of an indicator set for the EU, and the assessment of the size of these audiences. Section 5 discusses the results while also deriving policy implications for the effective engagement of HTR energy users. Section 6 concludes the paper and lays out a research agenda for further work.

2. METHODS AND DATA SELECTION

The methods of this paper follow a four-step approach. First, a literature review was conducted on HTR energy users, focusing on the non-residential sector and on the relevant barriers to their engagement. Second, based on the literature review, potential HTR audiences were systematized and a framework for non-residential HTR energy users was proposed. The goal was to detail the two groups mentioned by, *e.g.,* Rotmann *et al.* (2020), while avoiding intersecting them at this stage.

Third, the Eurostat database was explored with the goal of finding suitable indicators to quantify the systematized HTR audiences in the EU and its Member States. Key criteria for data selection included the availability of data for the whole period of 2011 to 2020 and the availability of data for the EU-27 (from 2020) group and for all current Member States. The original data was adjusted in order to be shown as a percentage of the total number of enterprises. The main data set used was from the Structural Business Statistics (SBS), including “number of enterprises” (SBS_SC_SCA_R2) according to the enterprises’ size and activity sector (Eurostat, 2022). Data on the “value added” and “persons employed” according to the enterprises’ size and to activity sector was also analysed (Eurostat, 2022).

Fourth, after the data selection and extracted, these indicators were analysed to assess the size of non-residential HTR audiences in the EU, as well as their evolution from 2011 to 2020 and their variation among Member States by looking at the minimum and maximum values for the EU-27 (from 2020) country group. These results fed the discussion of the paper and paved the way for a future research agenda on the topic of HTR energy users.

3. LITERATURE REVIEW: NON-RESIDENTIAL HARD-TO-REACH AUDIENCES

Rotmann *et al.* (2020) found a lack of literature on non-residential energy users, stating that this sector could almost be categorized as HTR in its entirety (excluding large enterprises and potentially offices which have been the focus of more research and policies). The same authors subdivide this sector in two broad groups, namely SMEs and commercial, which often overlap.

SMEs are defined by the European Commission (2020) as enterprises with less than 250 employees and an annual turnover of less than 50 million euro. Even if SMEs account for 99% of all businesses in the world and contribute significantly for energy use, research on their role in the energy transition is still scarce. Large companies, energy-intensive industries, and the public sector should theoretically be easier to reach by energy policies since they have facilitated access to finance and expertise, their number is small, and organizational structures are well-defined (Schlomann and Schleich, 2015). Conversely, SMEs engagement in energy issues through traditional policies and measures is seriously hindered by a wide range of barriers and vulnerabilities, such as lack of knowledge and shortage of funds (Sequeira and Melo, 2020). While common challenges affect most SMEs, the diversity of activities performed can lead to strikingly different energy use profiles and to a high degree of individuality (Sequeira and Melo, 2020). Cunha *et al.* (2020) found that the majority of SMEs in Portugal has never conducted an energy audit and do not have an energy manager. Likewise, Rotmann *et al.* (2020) found that the decision-making processes in SMEs are much more akin to those of households than they are to large enterprises. These authors call for research on different SME subsectors, that would enable to identify targeted solutions for individual business types.

Among main energy users, the services and commerce sector has the least amount of data available. This sector encompasses different sub sectors (e.g., offices, retail, food services, health care), with quite unique energy needs and uses, even if they are sometimes housed in relatively similar spaces (Rotmann *et al.*, 2020). Energy performance varies widely, with larger corporations and offices usually scoring higher, but there is few research on energy use and occupant behaviour in non-residential buildings. Therefore, general energy policies and support mechanisms often do not cater to the needs of this heterogeneous and complex HTR audience (Henriques and Catarino, 2016).

4. RESULTS

Proposing a framework for non-residential hard-to-reach energy users

Based on the literature review and on data availability, potentially HTR audiences of the non-residential sector were systematized in Fig. 1. The inclusion of offices as a HTR audience is not consistent across the literature, with some authors finding them easier to engage.

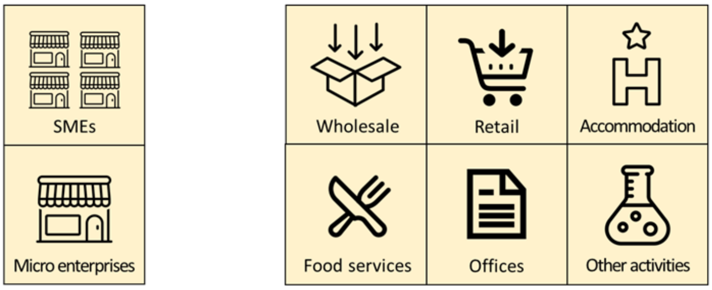


Fig. 1 – Proposed framework for systematized non-residential HTR audiences

Selecting an indicator set for the European Union

Table 1 shows the selected indicators for the systematized non-residential HTR audiences in the EU. The selection of indicators was conditioned by the striking lack of data on enterprises at EU scale.

Table 1 – Selected indicators for non-residential HTR audiences in the EU

Audience	Selected indicator	Method
SMEs	No. of enterprises by size class - Less than 250 employees	Adjusted
Micro-enterprises	No. of enterprises by size class - Less than 10 employees	Adjusted
Wholesale trade	No. of enterprises - Wholesale trade, except of motor vehicles	Adjusted
Retail trade	No. of enterprises - Retail trade, except of motor vehicles	Adjusted
Accommodation	No. of enterprises - Accommodation	Adjusted
Food services	No. of enterprises - Food and beverage service activities	Adjusted
Offices	No. of enterprises - Information and communication + Real estate activities + Administrative and support service activities	Calculated & adjusted
Other activities	No. of enterprises - Professional, scientific and technical activities	Adjusted

Assessing the size of hard-to-reach audiences in the European Union

Fig. 2 showcases the results for the selected indicators aiming to assess the size of the systematized non-residential HTR audiences in the EU, as a percentage of the total number of enterprises. Notably, SMEs and micro-enterprises represent around 99.8% and 93.5% of enterprises, respectively. While these segments account for the vast majority of enterprises by number, SMEs and micro-enterprises represent 53% and 19% of value added and 64% and 29% of persons employed, respectively.

Offices was the fastest growing activity from 2011 to 2020, representing around 17% of enterprises in 2020 and presenting a mostly uniform energy consumption profile, which is considered easier to reach by, *e.g.*, Rotmann *et al*. (2020). Activities such as retail, wholesale, and food services showed a relative downward trend from 2011 to 2020 in. These can present vastly different firmographics and energy use patterns even if they are often housed in similar spaces. Finally, “other activities” is a tremendously heterogeneous group which often presents very specific energy use characteristics.

Fig. 2 – Non-residential HTR audiences in the EU as a percentage of the total number of enterprises

Note that these indicators paint an average picture for the EU; there will be considerable variation between Member States. Table 2 showcases this variation by providing the minimum and maximum value, as percentage of total enterprises, and the respective Member State. SMEs and micro-enterprises represent the vast majority of enterprises in all Member States. Regarding the types of activities, differences can be found reflecting specific national contexts (*e.g.,* retail trade ranges from 5% of enterprises in Slovenia to 28% in Bulgaria). Nevertheless, we find that these audiences are significant in most Member States and that a more detailed national-scale analysis should be pursued.

Table 2 – Variation among Member States for systematized non-residential HTR audiences

HTR audiences	**2011** (% of total enterprises)			**2020** (% of total enterprises)		
	Min.	EU-27	Max.	Min.	EU-27	Max.
SMEs	99.5 (LU)	99.8	99.9 (PT)	99.5 (LU)	99.8	99.9 (GR)
Micro-enterprises	87.0 (LU)	92.8	96.0 (SK)	84.4 (DE)	93.5	97.4 (SK)
Wholesale trade	5.7 (IE)	8.3	13.3 (SK)	4.4 (HU)	7.0	10.1 (IT)
Retail trade	6.3 (SI)	16.9	32.1 (BG)	5.2 (SI)	13.7	27.9 (BG)
Accommodation	0.5 (BE)	1.3	4.9 (AT)	0.6 (BE)	1.5	4.8 (AT)
Food services	2.2 (LT)	7.0	10.7 (ES)	1.8 (LT)	6.4	10.7 (GR)
Offices	5.4 (GR)	14.5	27.0 (DK)	7.0 (GR)	17.3	30.2 (DK)
Other activities	10.4 (CY)	16.9	26.9 (NL)	13.6 (RO)	19.2	30.3 (NL)

5. DISCUSSION

Through this work, we do not intend to “write in stone” a rigid list of HTR audiences – a concept subject to criticism for being too broad – nor to define a fixed set of indicators (constrained due to lack of data availability). This is a highly context-specific concept that should reflect national and local dynamics. In contrast, we operationalized the HTR terminology aiming at sparking a discussion on the need to recognize the specific characteristics and needs of significant segments of the non-residential sector which are considered important for the energy transition. Following, we suggest that these might make them difficult to engage while we highlight their lack of recognition in traditional energy-related interventions. The results of this work can be relevant to inform the design of effective tailored and targeted policies and programs that target non-residential HTR audiences.

In this context, its highly relevant to assess effective interventions to engage with HTR audiences. Mundaca *et al.* (forthcoming) have reviewed 19 case-studies in 8 countries that have (implicitly or explicitly) targeted residential and non-residential HTR groups, finding that proper mapping of audiences, definition of behaviours, design of content, effective delivery of the intervention, and conduction of an ex-post evaluation are key to determine their success. In particular, Sequeira *et al*. (2021) analysed a case-study in Portugal that targeted SMEs of the services and commerce sector, arguing for the importance of action at local-scale with the involvement of trusted community middle actors to provide both technical and financial support.

6. CONCLUSIONS

In this work we have explored the HTR energy users concept in the EU, particularly looking at the non-residential sector and finding that the SME group represents over 99% of all enterprises in the EU with the hardest-to-reach segment of micro-enterprises accounted for around 93%. The relative importance of specific subsectors varies among Member States and this should be subjected to further analysis –data limitation is a key concern. While the concept of energy poverty is not easily transferred to the non-residential sector, the term energy burden (used in the United States) can be useful to conceptualize the challenges related to energy costs in the non-residential sector. Considering the ongoing energy crisis, non-residential HTR audiences may be at exacerbated risk of increased energy burdens which may affect businesses viability in often already constrained sectors of activity. Thus, we hope that this paper offers a useful approach to recognize the HTR nature of specific audiences in energy policies. After gauging at the potential size of HTR audiences, we argue that the next step is to propose effective approaches to reach the HTR.

REFERENCES

Ambrose, A., Baker, W., Batty, E., and MacNair Hawkins, A. (2019). Focus Article: “I have a panic attack when I pick up the phone”: experiences of energy advice amongst ‘hard to reach’ energy users. People, Place and Policy, 14(1). https://doi.org/10.3351/ppp.2019.3479427335

Ashby, K., Smith, J., Rotmann, S., Mundaca, L., and Ambrose, A. (2020). HTR Characteristics. HTR Annex by Users TCP by IEA: Wellington. https://doi.org/10.47568/3XR102

Cunha, P., Almeida Neves, S., Cardoso Marques, A., and Serrasqueiro, Z. (2020). Adoption of energy efficiency measures in the buildings of micro-, small and medium-sized Portuguese enterprises. Energy Policy, 146, 111776. https://doi.org/10.1016/j.enpol.2020.111776

European Commission (2020). User guide to the SME definition. Luxembourg: Publications Office of the European Union. https://doi.org/0.2873/255862

Eurostat (2022). Structural Business Statistics (SBS). Update: 27/10/2022. Consulted: 13/12/2022.

Henriques, J., and Catarino, J. (2016). Motivating towards energy efficiency in small and medium enterprises. Journal of Cleaner Production, 139, 42-50. http://dx.doi.org/10.1016/j.jclepro.2016.08.026

Mundaca, L., Rotmann, S., Ashby, K., Karlin, B., Butler, D., Sequeira, M.M., Gouveia, J.P., Palma, P., Realini, A., Maggiore, S., and Feenstra, M. (forthcoming). Hard-to-Reach Energy Users: Lessons from the assessment of nineteen energy behaviour change programmes across eight countries.

Rotmann S., Mundaca L., Castaño-Rosa R., O’Sullivan K., Ambrose A., Butler D., Marchand R., Chester, M., Karlin, B., Chambers J., and K. Ashby (2020). Hard-to-Reach Energy Users: A critical review of audience characteristics and target behaviours. User-Centred Energy Systems TCP - HTR Annex: Wellington. 250pp. https://userstcp.org/task/hard-to-reach-energy-users/

Schlomann, B., and Schleich, J. (2015). Adoption of low-cost energy efficiency measures in the tertiary sector – an empirical analysis based on energy survey data. Renewable and Sustainable Energy Reviews, 43, 1127-1133. https://doi.org/10.1016/j.rser.2014.11.089

Sequeira, M., and Melo, J.J. (2020). Energy saving potential in the small business service sector: case study Telheiras neighborhood, Portugal. Energy Efficiency, 13, 551-569. https://doi.org/10.1007/s12053-020-09842-y

Sequeira, M.M., Gouveia, J.P. and Palma, P. (2021). Case Study Analysis – PORTUGAL. HTR Task Users TCP by IEA: Lisbon. 38pp. https://doi.org/10.47568/3XR115

ASSESSING THE LITERATURE ON ENERGY TRANSITION AND ECONOMICS IN LATIN AMERICA: AN IMPACT AND CENTRALITY ANALYSIS

Vitor Benfica1, António Cardoso Marques[2]

[1]Universidade Beira Interior (Portugal), vitor.benfica@ubi.pt
[2] NECE-UBI, University of Beira Interior, Rua Marquês d'Ávila e Bolama, 6201-001 Covilhã, Portugal, amarques@ubi.pt

Abstract

Energy transition is a historical phenomenon that has manifested throughout the development of human society and can be exemplified through various changes in the use of energy sources, such as the transition from wood to coal, from coal to oil, and currently to renewable energy sources. This process occurs when the proportion of use of an energy source surpasses the dominant source.
The purpose of this study is to evaluate the progress of literature on energy transition in Latin America by applying the clustering method to group studies and using impact and centrality indices to categorize clusters based on relevance and development.
The results indicate that studies on the subject mainly focus on public policies aimed at promoting energy transition and its effects on reducing greenhouse gas emissions. There is also emerging literature on the socio-environmental impacts of energy projects, but few studies focus on social issues such as energy poverty and participation instruments. Thus, this study reveals that the literature on the subject may follow different paths than those usually adopted by developed nations.

Keywords: review, energy transition, Latin America, clustering by coupling.

1. Introduction

Since the advent of the Industrial Revolution, access to energy has become a fundamental element of human life. Nowadays, the energy transition goes beyond the mere substitution of energy sources used in production and consumption for others with lower greenhouse gas emissions and encompasses a broader concept of making energy production more efficient, sustainable, and clean while promoting social justice.
The change in the energy matrix is especially relevant in the current context, as the post-pandemic period is tending toward an increase in energy consumption in parallel with the search for increased population income, triggering greater energy demand and pressuring the exploitation of non-renewable sources. The energy transition involves several changes in energy production technologies, how people consume energy, and how energy policies are formulated and implemented by the government. This transition process is crucial to address the challenges of global warming and has gained more prominence in the decision-maker's agenda in the post-COVID-19 pandemic context and particularly with the developments in the war in Ukraine (IEA, 2020).
The energy transition context presents significant variations among nations, making the development of generalized solutions inadequate. In Latin America, the energy transition is occurring in a particularly challenging context, as the region is marked by profound economic and social inequalities, mainly poverty, which further intensifies the obstacles faced in this transition.
The growing concern about understanding the changes in the energy sector and their consequences in the current environmental crisis has driven the production of extensive literature on energy transitions. The fundamental purpose is to learn lessons and promote changes in the global energy matrix (Smil, 2016; Sovacool, 2016). Several studies have evaluated the impacts of access to energy on well-being, health, and professional skill development, which directly reflect work productivity.

Currently, there is a growing body of literature addressing alternatives for energy transition. According to Vigoya et al. (2020), the United States has been making efforts to reduce its dependence on oil by increasing the production of natural gas and biodiesel. Similarly, Europe aims to enhance energy efficiency and the use of renewable energy sources. On the other hand, China has emerged as a major investor in renewable energy, responsible for almost half of the global investments in this field. However, Jeifets et al. (2021) observe that the solutions adopted by developed countries are not suitable for the reality of Latin American countries. Additionally, Semenov (2022) emphasizes the need to evaluate the social and environmental impacts of new ventures, as the intermittent nature of these projects complicates their assessment.

2. Methods and data

The data used in the present research were obtained through the Web of Science (WoS) and Scopus platforms. To conduct the search, the term “energy transition” and its corresponding synonyms “energy transitions,” “energetic transition,” “energetic transitions,” “energy shift,” “energy shifts,” “energy change,” and “energy changes” were employed. The search was restricted to articles published in their final version and made available as open access.

The second phase of the work selection process involved a thorough evaluation of titles, keywords, and abstracts to identify those that clearly address some relevant aspects related to energy transition. Duplicate papers were removed from the databases, and the analysis was limited to a specific location, country, or the entire Latin American region, resulting in a sample of 79 articles.

The selected articles were then evaluated using the Bibliometrix module, a commonly used tool in bibliometric analyses that employs R language to assess the development of academic research on the topic. The Clustering by Coupling method was employed to identify the principal areas of interest and related research topics, while the Calon centrality indices were used to evaluate the driving themes of the research.

Clustering by Coupling is a technique that aims to analyze a third publication mentioned in two selected publications for the sample. This approach focuses on the overlap of literature between publications, where the greater the overlap, the stronger the relationship between the considered publications. To include the most influential articles that are grouped with other publications, coupling was configured to identify documents with at least five citations in common. This restriction was established to exclude most articles that do not group with other elements and are therefore excluded by the software algorithm Cobo (2011).

The centrality and density indices proposed by Callon et al. (1991) were used to identify which themes are driving, basic, isolated, or emerging. The concept of centrality measures the strength of external connections with other themes and can therefore be used to measure of the importance of a theme in the overall development of the research field. The same author proposed the concept of density to measure the internal strength of a network. Density is a measure of the strength of internal ties among all the keywords that describe the research topic and can therefore be used as a measure of the topic's development.

3. Results

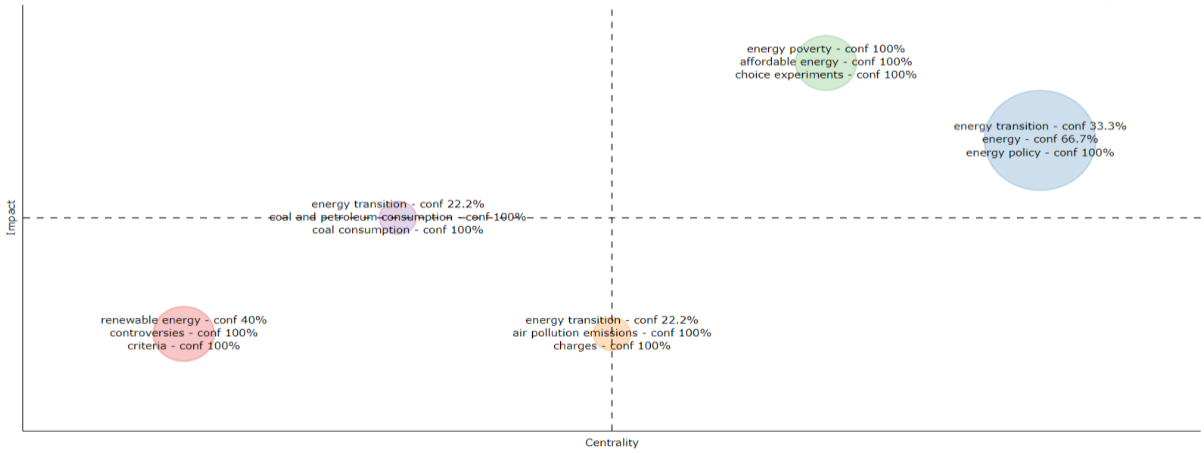
The findings indicate that research on the topic of energy transition can be classified into five distinct groups. The first group, called Group A, consists of the works of Santillán Vera et al. (2023), Vazquez and Hallack (2018), and Zarate-Toledo et al. (2021), who share a narrative about regulation often adopting a superficial view of sustainability, assuming that renewable energy is “green” and environmentally “friendly” by definition, which ignores the potential negative impacts of renewable energy production, especially when it is not adequately regulated.

The second group, called Group B, is more comprehensive and includes the works of Alvial-Palavicino and Opazo-Bunster (2018), Blanco et al.(2017), Bradshaw and Jannuzzi (2019), Correa et al. (2022), Santos Carstens dos and da Cunha (2019), Ramirez (2022), and Viviana and Castillo (2019). In this group, the discussion of the role of the state in promoting the development and implementation of renewable energy projects is a recurring theme, with some case studies evaluating the importance of fiscal policies to enable such projects. In addition, some studies highlight the importance of promoting information exchange among stakeholders, reporting the positive effect of including affected populations in the projects.

Cluster C comprises the papers by Calvo et al. (2022), Hancevic et al. (2022), and Martinez-Cruz & Nunez (2020). The thematic core of this cluster lies in the economic effects of adopting recent technologies in the industrial sector. A common feature among these studies is the assessment of Mexican government policies, reported as being coercive.

Cluster D, on the other hand, is formed by the papers authored by Calvo et al. (2022), Coelho et al. (2018), and Schueftan et al. (2021). The shared characteristic of this group is the evaluation of public policies aimed at promoting energy efficiency, highlighting the importance of including low-income populations in the development of transition policies.

Cluster E is composed of the papers by Bertoni & Roman (2013) and Mar Rubio & Folchi (2012). These papers assess the energy transition away from coal in Latin America, with key points focusing on the rapid technological transition due to low technological dependence. Unlike developed economies, developing economies do not need to wait for the end of the useful life of enterprises to implement recent technologies.



Callon et al. (1991) define centrality as a measure of a theme's relevance in a research area and density as a measure of its development. Themes located in the upper right quadrant are considered the most important for structuring a research field, as they exhibit high centralization and density. These themes, known as “motor-themes” have strong external connections and are related to concepts applicable to other topics that are conceptually close.

On the other hand, themes in the upper left quadrant have well-developed internal connections but unimportant external connections, making them marginally important to the research field. These themes are highly specialized and peripheral in character. Themes in the lower left quadrant are considered weak and marginal, with low density and centrality, representing mainly emerging or declining topics. Themes in the lower right quadrant are important to the research field but are not fully developed, grouping together transversal, general, and basic topics.

To classify works into a specific cluster, the following criterion is adopted: a probability of 0.8 or higher almost certainly indicates that they belong to that cluster, while a probability between 0.4 and 0.8 indicates a high probability of belonging to that cluster. An article may address multiple topics and, therefore, may belong to more than one cluster. To simplify the analysis, the term with the greatest importance of the representative work in the cluster is selected (Callon et al., 1991).

4. Conclusion

The present study aimed to understand the current state of theoretical development regarding energy transition. Cluster analysis by coupling was employed to examine the overlap between publications, and it was found that the greater the overlap, the stronger the relationship between them. The analysis revealed a concentration of works on topics related to public policies that encourage the use of renewable sources, while energy poverty is often addressed in the context of energy efficiency, referring to the ability to acquire new equipment.

Some publications question the "green" notion of ventures, as many fail to adequately assess the social and environmental impacts they may cause. Ultimately, it is expected that regions with lower technological dependence in their production matrix will be able to transition more quickly than already developed regions.

By using measures of centrality and density, it was observed that research related to the technological transition of energy sources dominates the literature, while topics related to controversies around renewable sources emerge as a new theme. Furthermore, the term "energy poverty" is addressed in publications that evaluate technological substitution policies.

In summary, this article sought to discuss the current development of the literature on energy transition to shed light on the trajectory that the literature has taken. Whilst the existing literature covers many aspects of energy transition, novel studies should be conducted to improve understanding of the issue.

REFERENCES

Alvial-Palavicino, C., & Opazo-Bunster, J. (2018). Looking back to go forward? The interplay between long-term futures and political expectations in sustainability transitions in Chile. Em FUTURES (Vol. 104, p. 61–74). ELSEVIER SCI LTD. https://doi.org/10.1016/j.futures.2018.07.005

Bertoni, R., & Roman, C. (2013). The rise and fall of mineral coal in Uruguay. A historical analysis from the last decades of the 19th century to the present. Em REVISTA DE HISTORIA ECONOMICA (Vol. 31, Número 3, p. 459–497). CAMBRIDGE UNIV PRESS. https://doi.org/10.1017/S0212610913000207

Blanco, G., Amarilla, R., Martinez, A., Llamosas, C., & Oxilia, V. (2017). Energy transitions and emerging economies: A multi-criteria analysis of policy options for hydropower surplus utilization in Paraguay. Em ENERGY POLICY (Vol. 108, p. 312–321). ELSEVIER SCI LTD. https://doi.org/10.1016/j.enpol.2017.06.003

Bradshaw, A., & Jannuzzi, G. de M. (2019). Governing energy transitions and regional economic development: Evidence from three Brazilian states. Em ENERGY POLICY (Vol. 126, p. 1–11). ELSEVIER SCI LTD. https://doi.org/10.1016/j.enpol.2018.05.025

Callon, M., Courtial, J. P., & Laville, F. (1991). Co-word analysis as a tool for describing the network of interactions between basic and technological research: The case of polymer chemsitry. Scientometrics, 22(1), 155–205. https://doi.org/10.1007/BF02019280

Calvo, R., Alamos, N., Huneeus, N., & O'Ryan, R. (2022). Energy poverty effects on policy-based PM2.5 emissions mitigation in southern and central Chile. Em ENERGY POLICY (Vol. 161). ELSEVIER SCI LTD. https://doi.org/10.1016/j.enpol.2021.112762

Cobo, M. J., López-Herrera, A. G., Herrera-Viedma, E., & Herrera, F. (2011). An approach for detecting, quantifying, and visualizing the evolution of a research field: A practical application to the Fuzzy Sets Theory field. Journal of Informetrics, 5(1), 146–166. https://doi.org/10.1016/j.joi.2010.10.002

Coelho, S. T., Sanches-Pereira, A., Tudeschini, L. G., & Goldemberg, J. (2018). The energy transition history of fuelwood replacement for liquefied petroleum gas in Brazilian households from 1920 to 2016. Em ENERGY POLICY (Vol. 123, p. 41–52). ELSEVIER SCI LTD. https://doi.org/10.1016/j.enpol.2018.08.041

Correa, K. C., Uriona-Maldonado, M., & Vaz, C. R. (2022). The evolution, consolidation, and future challenges of wind energy in Uruguay. Em ENERGY POLICY (Vol. 161). ELSEVIER SCI LTD. https://doi.org/10.1016/j.enpol.2021.112758

dos Santos Carstens, D. D., & da Cunha, S. K. (2019). Challenges and opportunities for the growth of solar photovoltaic energy in Brazil. Em ENERGY POLICY (Vol. 125, p. 396–404). ELSEVIER SCI LTD. https://doi.org/10.1016/j.enpol.2018.10.063

Energy transformations for net-zero emissions – Energy Technology Perspectives 2020 – Analysis. (2020). IEA. https://www.iea.org/reports/energy-technology-perspectives-2020/energy-transformations-for-net-zero-emissions

Hancevic, P., I., Nunez, H. M., & Rosellon, J. (2022). Electricity Tariff Rebalancing in Emerging Countries: The Efficiency-equity Tradeoff and Its Impact on Photovoltaic Distributed Generation. Em ENERGY JOURNAL (Vol. 43, Número 4, p. 69–93). INT ASSOC ENERGY ECONOMICS. https://doi.org/10.5547/01956574.43.4.phan

Jeifets, V., & Pravdiuk, D. (2021). The "green renewal" conception in Latin America: Chances of a steady transformation in post-pandemic times. IBEROAMERICA, 3, 101–124. https://doi.org/10.37656/s20768400-2021-3-05

Martinez, N., & Komendantova, N. (2020). The effectiveness of the social impact assessment (SIA) in energy transition management: Stakeholders' insights from renewable energy projects in Mexico. Em ENERGY POLICY (Vol. 145). ELSEVIER SCI LTD. https://doi.org/10.1016/j.enpol.2020.111744
Ramirez, J., Angelino Velázquez, D., & Vélez-Zapata, C. (2022). The potential role of peace, justice, and strong institutions in Colombia's areas of limited statehood for energy diversification towards governance in energy democracy. Energy Policy, 168, 113135–113135. https://doi.org/10.1016/j.enpol.2022.113135
Rubio, M. d. M., & Folchi, M. (2012). Will small energy consumers be faster in transition? Evidence from the early shift from coal to oil in Latin America. Energy Policy, 50, 50–61. https://doi.org/10.1016/j.enpol.2012.03.054
Santillán Vera, M., García Manrique, L., Rodríguez Peña, I., & De La Vega Navarro, A. (2023). Drivers of electricity GHG emissions and the role of natural gas in mexican energy transition. Energy Policy, 173, 113316. https://doi.org/10.1016/j.enpol.2022.113316
Schueftan, A., Aravena, C., & Reyes, R. (2021). Financing energy efficiency retrofits in Chilean households: The role of financial instruments, savings, and uncertainty in energy transition. Em RESOURCE AND ENERGY ECONOMICS (Vol. 66). ELSEVIER. https://doi.org/10.1016/j.reseneeco.2021.101265
Semenov, V. (2022). Energy transition in Latin America and Russia. IBEROAMERICA, 1, 87–110. https://doi.org/10.37656/s20768400-2022-1-04
Smil, V. (2016). Examining energy transitions: A dozen insights based on performance. Energy Research & Social Science, 22, 194–197. https://doi.org/10.1016/j.erss.2016.08.017
Sovacool, B. K. (2016). How long will it take? Conceptualizing the temporal dynamics of energy transitions. Energy Research & Social Science, 13, 202–215. https://doi.org/10.1016/j.erss.2015.12.020
Vazquez, M., & Hallack, M. (2018). The role of regulatory learning in energy transition: The case of solar PV in Brazil. Energy Policy, 114, 465–481. https://doi.org/10.1016/j.enpol.2017.11.066
Vigoya, M. F., Mendoza, J. G., & Abril, S. O. (2020). INTERNATIONAL ENERGY TRANSITION: A REVIEW OF ITS STATUS ON SEVERAL CONTINENTS. International Journal of Energy Economics and Policy, 10(6), 216–224. https://doi.org/10.32479/ijeep.10116
Viviana, M., & Castillo, O. L. (2019). Colombian energy planning—Neither for energy, nor for Colombia. Em ENERGY POLICY (Vol. 129, p. 1132–1142). ELSEVIER SCI LTD. https://doi.org/10.1016/j.enpol.2019.03.025
Zarate-Toledo, E., Wood, P., & Patin, R. (2021). In search of wind farm sustainability on the Yucatan coast: Deficiencies and public perception of Environmental Impact Assessment in Mexico. Em ENERGY POLICY (Vol. 158). ELSEVIER SCI LTD. https://doi.org/10.1016/j.enpol.2021.112525

CONSEQUENCES OF THE ENERGY TRANSITION ON POVERTY AND DEPENDENCE IN COUNTRIES IN THE SADC REGION: AN ANALYSIS OF PANEL DATA FROM 2000-2021

Querubim Capimolo Lucamba[1], António Cardoso Marques[2], Diogo André Pereira[3]

[1]Universidade Beira Interior (Portugal), querubim.lucamba@ubi.pt
[2]NECE-UBI, University of Beira Interior, Rua Marquês d'Ávila e Bolama, 6201-001 Covilhã, Portugal, amarques@ubi.pt
[3]NECE-UBI, University of Beira Interior, Rua Marquês d'Ávila e Bolama, 6201-001 Covilhã, Portugal, diogo.andre.pereira@ubi.pt

Overview

A paradigm shifts from energy consumption based on non-renewable sources to energy consumption with renewable sources is crucial to reduce the pressure on the environment and ensure the sustainability of the universe itself. It is obvious that the transition that is so often talked about and sought to be achieved will not be made from one day to the next. More than time, a common strategy or objective is needed, otherwise we may leave other more vulnerable countries behind and consequently increase the levels of energy poverty. The discussion around energy poverty does not have a common consensus at the level of the authors who have raised the debate in the scientific branch over time. It is in this vein that before examining energy poverty, it may be useful to establish what we mean by the term 'energy' in this research paper (Day et al., 2016).

This research focuses on the consequences of the energy transition with a finer analysis focusing on energy poverty in countries of the SADC (southern African development community) region. We think it is a work that proves to be innovative in terms of novelty and contributes in the following ways: (1) the effect that a particular energy source could have on energy poverty alleviation and (2) presents empirical results through a panel data-based framework with an annual database. (Birol, 2020.), 2020;(Murshed, 2020.) The starting point of energy efficiency itself is related to transition from polluting cooking fuels to clean ones. As for example, the use of traditional fossil fuels for cooking does not need state-of-the-art technology for its realization, whereas the use of clean cooking fuels requires the use of modern technologies, which in return the latter can translate into improvements for the environment and an efficiency in the. Energy use in an economy (Birol, 2020). In this regard, it is important to bear in mind that countries whose main source of energy for cooking is fossil fuels will be more averse to energy efficiency in terms of their gains, thus compromising the energy transition (Al-tal et al., 2021). It is in this perspective that we seek to answer the following research questions; how the countries in the SADC region are dealing with the consequences of energy transition and what public policies should be triggered to mitigate energy poverty in this region, which by the way are countries highly dependent on non-renewable resources. In short, these two questions allow us to outline two objectives that by the way can help in designing adequate energy public policies for the energy mix of these countries, and this is the main motivation for this research.

Thus, our research aims to provide guidelines mitigating the consequences of the energy transition on poverty, as well as a discussion on the effects of using clean energy for cooking on energy poverty reduction and finally an approach on the substitution effect that electricity can provide for poverty reduction. The first tests of our research led us to use the Autoregressive distributed lag (ARDL) approach, which allowed us to decompose the total effects into short and long run effects, to answer the following questions: (i) does the use of clean energy for cooking contribute to the reduction of energy poverty in these countries? (ii) does electricity have a substitution effect on clean energy for cooking? (iii) is the energy transition experienced by these countries increasing the risk of poverty or social exclusion of households?

2. Methods

To achieve the main objective and answer the questions raised, we used a panel database for 16 SADC countries for the period 2000 to 2020 (annual data) from the source World health Organization and World Development Indicators. This study assesses the effect of Clean energy consumption for cooking on energy poverty reduction and to compete for these objectives the following variables were pooled: (Y) clean cooking energy consumption; (x1) fossil cooking energy consumption; (x2) household income; (x3) foreign direct investment; (x4) total renewable energy consumption; (x5) energy intensity; (x6) energy access; (x7) total natural resources; (x8) Gini per capita; (x9) Biomass; (x10) Coal; (x11) electricity; (x12) Gas; (x13) kerosone and (x14) charcoal. In addition, this research seeks to understand the substitution effect that electricity causes both the installed capacity and the specific sources. Taking into account the characteristics of the countries it is expected that biomass will decrease consumption of clean energy for cooking in the short term, that is, due to the high costs that families will have to bear to have this technology in their homes, which will leave out those families with few resources, but in the long term this situation is reversed that is, the consumption of clean energy for cooking will become cheaper and accessible to all as already argued in the literature. Thus, an ARDL methodology was applied to study these dynamic effects. In addition, a battery of model specification tests was carried out, indicating that the Driscoll and Kraay estimator with fixed effects is the most appropriate estimator to deal with the characteristics of the data.

3. Results

The first results clearly show us the sustainability that the consumption of clean energy for cooking can provide for the set of countries studied, when we observe that sources from biomass decrease in the long term, thus reducing energy poverty and even cardiovascular diseases according to WHO (world health organization) report 2021. The consumption of clean energy for cooking significantly reduces fossil energy consumption in the long term, thus contributing to the achievement of the SDGs that the countries are committed to.

Tabela 1- Testes das variáveis parcimónias

Variable		lny		lnx1			lnx11		
	cse	rse	dk	cse	rse	dk	cse	rse	dk
ECM	-0.0371***	-0.0371***	-0.0371***	-0.0983***	-0.0983***	-0.0983***			
llnx2	0.0227	0.0227*	0.0227***				0.0235***	0.0235**	0.0235***
lx3	0.0000***	0.0000***	0.0000***	0.0000*	0	0.0000**			
llnx4	0.0600**	0.0600***	0.0600***	-0.0283***	-0.0283	-0.0283**	-0.0347***	-0.0347*	-0.0347***
llnx5	0.0639***	0.0639	0.0639**						
llnx6							0.0116***	0.0116*	0.0116***
llnx7	0.0128*	0.0128	0.0128**				0.0084**	0.0084	0.0084**
llnx8	0.0257	0.0257	0.0257*				-0.0246***	-0.0246**	-0.0246**
llnx9	-0.0471	-0.0471	-0.0471*	0.1415***	0.1415***	0.1415***	0.0703***	0.0703**	0.0703***
llnx11				-0.0314***	-0.0314**	-0.0314***	-0.0331***	-0.0331	-0.0331**
llnx12	0.1106***	0.1106**	0.1106***						
llnx13	0.0637**	0.0637	0.0637***	0.0564***	0.0564**	0.0564***			
llnx14				0.0162**	0.0162	0.0162**	-0.0439***	-0.0439**	-0.0439***
_cons	-0.4938**	-0.4938	-0.4938***	0.6435***	0.6435***	0.6435***	0.0047	0.0047	0.0047

It should be noted that it is not the objective of this summary to exhaust all the results that this research proposed, however, only the results relating to the impact of biomass consumption and fossil sources on the consumption of clean energy for cooking are presented because the results relating to the risk of poverty and other variables tested are in agreement with them, for example with regard to household income our research concluded that the consumption of fossil energy for cooking is leaving poorer households. This means that poor households do not have enough income to guarantee their livelihoods, which may decrease their productivity and future income, meaning that poor households may fall into the energy poverty trap in SADC member countries.

4. Conclusions

The results of our research show that the consumption of fossil energy for cooking continues to increase the rate of energy poverty in countries of the SADC region, and the same shows us that the most plausible way to overcome this problem is for countries to implement policies that allow the rapid introduction of clean or renewable energy sources in the energy mix of member countries, since the consumption of this type of energy contributes to the reduction of energy poverty and helps to make the world more sustainable to ensure the continuity of populations. Therefore, political decision-makers must design energy policies that promote the introduction of renewable energy sources.

References

Al-tal, R., Murshed, M., Ahmad, P., Alfar, A. J. K., Bassim, M., Elheddad, M., Nurmakhanova, M., & Mahmood, H. (2021). The non-linear effects of energy efficiency gains on the incidence of energy poverty. *Sustainability (Switzerland)*, *13*(19). https://doi.org/10.3390/su131911055.
Birol, F. (n.d.). *Technology Perspectives Energy Special Report on Clean Energy Innovation Accelerating technology progress for a sustainable future Energy Technology Perspectives Foreword Special Report on Clean Energy Innovation Acknowledgements Special Report on Clean Energy Innovation*.
Day, R., Walker, G., & Simcock, N. (2016). Conceptualising energy use and energy poverty using a capabilities framework. *Energy Policy*, *93*, 255–264. https://doi.org/10.1016/j.enpol.2016.03.01.

EXPLORING PERCEPTIONS OF COMPETING AGENDAS IN PORTUGUESE CARBON NEUTRALITY POLICIES

Katherine Mahoney[1a], João Pedro Gouveia[1], Rita Lopes[1], Siddharth Sareen[2]

[1] CENSE – _Center for Environmental and Sustainability Research & CHANGE - Global Change and Sustainability Institute, NOVA School of Science and Technology, NOVA University Lisbon, Campus de Caparica, 2829-516, Caparica, (PORTUGAL),
[a] k.mahoney@campus.fct.unl.pt
[2] Department of Media and Social Sciences, University of Stavanger, 4036 Stavanger (NORWAY)

Keywords: Energy poverty, Carbon-neutrality policy, Just transition, Stakeholder interviews

1. INTRODUCTION

The links between energy poverty (EP), energy transition (ET), and climate change (CC) policy are multifaceted and complex, with a series of shared topics bridging these agendas. Importantly while there has been a strong focus from European political bodies on the synergies between energy and climate policies for energy poverty alleviation (Publications Office of the European Union, 2019), there is increasing concern regarding the trade-offs between the various policy initiatives. Critically it has been recognised that what is beneficial for one policy agenda may come at the cost of realizing the goals for another (McCoy and Kotsch, 2020), (Sherriff et al., 2022), demonstrating that a careful evaluation of these policies is necessary to monitor their progress in the different domains (Mahoney et al., 2022).
Simultaneously, it is generally agreed that successful implementation of the energy transition depends upon the interaction and co-operation of numerous actors with varying interests (Fernandez et al., 2021), with the transition process inherently implying disruption for the traditional players in the energy sector. Working on the premise that carbon neutrality policies in our selected case, Portugal, provide insightful examples of these competing agendas in practice, we apply a thematic analysis to exploratory interviews carried out with expert stakeholders to assess perceptions of areas of competition and synergy in carbon neutrality policies. We base this assumption on the grounds that Portugal has progressed rapidly with the energy transition but presents a significant vulnerability to energy poverty (Gouveia et al., 2019).

2. METHODOLOGY

We applied an exploratory qualitative interview approach, conducting 39 semi structured interviews. Interviewees with expertise in the CC, ET, and EP agendas were sought for the interviews, these were targeted through a combination of personal connections, contact of groups allocated with responsibility for these agendas in key policy documents, and the snowball effect (Bryman, 2012). The interviews were carried out in English or Portuguese as appropriate. Interviews were recorded and subsequently transcribed with the participant's consent. The NVivo software tool was used to deductively code and analyze the interviews, where the responses to each question were coded under a corresponding thematic heading.

3. RESULTS

The following section presents the results of our analysis, The policy-related question themes and interviewee responses are elaborated in Table. 1. Following these open-ended questions, interviewees were asked to comment on specific contemporary policies and related funding schemes.

Our findings reveal a general consensus among stakeholders that CC, ET, and EP agendas should be linked but unearth differences in opinion on how this transpires at the practical level. We found that organisations defining agendas as separate were those with a high level of consumer contact rather than those who were designing policy (NGOs, Environmental & Energy Agencies, Universities, Cooperatives). The stigma associated with the term "energy poverty" in Portugal was highlighted by stakeholders from NGOs, Environmental & Energy Agencies, and a Political Party.
Table 1. Interview responses by question theme

Question theme	Overall perceptions	Key quotes
Views on whether CC, ET and EP agendas are linked or separate	Links at theoretical level but less clear links at practical level	*"Looking at them, as if they were different things, this can bring unexpected consequences which could even be prejudicial for other sectors" Interview PT027*
Awareness of and capacity to participate in CC & ET agendas	Agendas so pervasive that some level of familiarity was inevitable	*"It's like this, I think currently it's a problem, it's a theme that doesn't escape anyone it seems that, I think everyone is aware" Interview PT030*
Views on public awareness of EP and ability to mitigate	EP term is unknown but people recognise the symptoms e.g., being uncomfortable in the home.	*"I think that uh, ah it´s a concept which is very unknown, practically unknown" Interview PT019*

Important findings regarding current policies included perceptions that an energy efficiency programme dedicated to EP consumers, the "Vale Eficiência," offered insufficient funding to help those most in need. Limits such as digital and general literacy were identified as reducing access to the benefits of ET policies and corresponding funding for those in EP. Several interviewees also noted that the current funding levels dedicated to energy efficiency in Portugal are far below what is required. Palma et al. (2022) unfold a total investment for deep energy renovation of the passive structure of Portuguese dwellings (i.e., windows replacement and insulation of roofs, floors and walls) of around 72000 million euros; whereas the currently allocated funding available from the recovery resilience plan to private housing energy efficiency improvements is only around 250 million.

4. CONCLUSIONS

Our interviews explored the agendas of CC, ET, and EP in Portugal with specific reference to the current policy context. Importantly, we engaged with key stakeholders in the Portuguese ET to evaluate their perspectives and how they were relevant to policy outcomes. While we revealed general areas of agreement between stakeholder groups, we also revealed differences in the perceptions of these groups regarding how policy was being received at the consumer level. Critically the fitness for purpose of the current policy approach was called into question. Understanding these different perceptions and their implications for policy design is ultimately highly important for improving policy synergy.

REFERENCES

Bryman, A. (2012). *Social Research Methods*. 4th Edition. Oxford University Press

Fernandez, R., Schoenefeld, J, J., Hoerber, T., Oberthür, S. (2021) Europe's Transition to Sustainability: Actors, Approaches and Policies, *The International Spectator*, 56:3, 1-6. https://doi.org/10.1080/03932729.2021.1966188

Gouveia, J.P., Palma, P., Simoes, S. (2019). Energy poverty vulnerability index:. A multidimensional tool to identify hotspots for local action. *Energy Reports*. 5. 187-201. https://doi.org/10.1016/j.egyr.2018.12.004

Mahoney, K., Gouveia, J, P., Lopes, R., Sareen, S. (2022). Clean, green and the unseen: The CompeSA framework | Assessing Competing Sustainability Agendas in Carbon Neutrality Policy Pathways. *Global Transitions*. 4 pp. 45-57. https://doi.org/10.1016/j.glt.2022.10.004

McCoy, D., Kotsch, A. (2020). Quantifying the distributional impact of energy efficiency measures. Centre for Climate Change Economics and Policy Working Paper No. 340. The Grantham Research Institute on Climate Change and the Environment. Available at: https://www.lse.ac.uk/granthaminstitute/wp-content/uploads/2020/02/working-paper-306-McCoy-Kotsch-Feb-2020.pdf

Palma, P., Gouveia, J.P., Barbosa, R. (2022). How Much will it Cost? An energy renovation analysis for the Portuguese dwelling stock. Sustainable Cities and Society. Volume 78, March 2022, 103607. https://doi.org/10.1016/j.scs.2021.103607

Publications Office of the European Union. (2019). *Directorate-General for Energy, Clean energy for all Europeans*, Publications Office, (April 2023), https://data.europa.eu/doi/10.2833/9937

Sherriff, G. Butler, D., Brown, P. (2022). The reduction of fuel poverty may be lost in the rush to decarbonise': Six research risks at the intersection of fuel poverty, climate change and decarbonization. *People, Place and Policy*. 1-20. https://doi.org/10.3351/ppp.2022.3776894798

ASSESSING THE ECONOMIC IMPACTS OF THE CHILEAN ENERGY TRANSITION: AN INPUT-OUTPUT HYBRID EQUILIBRIUM MODEL

Tomás Ochoa[1], Diego Vera[2], Esteban Gil[3], George Kerrigan[4], Víctor Hinojosa[5]

[1]Imperial College London (UNITED KINGDOM), t.ochoa@imperial.ac.uk
[2]Universidad Técnica Federico Santa María (CHILE), diego.vera.14@sansano.usm.cl
[3]Universidad Técnica Federico Santa María (CHILE), esteban.gil@usm.cl
[4]Universidad Técnica Federico Santa María (CHILE), george.kerriganr@usm.cl
[5]Universidad Técnica Federico Santa María (CHILE), victor.hinojosa@usm.cl

Abstract

This paper proposes an Input-Output Hybrid Equilibrium (IO-HE) model to assess the impacts of the energy transition on the economy and the environment as emerging technologies are deployed. To achieve this, we explicitly represent technologies such as energy storage, renewable energy generation, and green hydrogen in the model. Our approach combines a top-down (TD) and a bottom-up (BU) model, which are calibrated using an optimization program. Preliminary results of the model using Chilean data demonstrate the potential of the proposed approach to inform policy-makers about the effects of energy transition scenarios in the Chilean context.

Keywords: Hybrid equilibrium models, energy transition, green hydrogen, renewable generation.

1 INTRODUCTION

The adoption of green hydrogen and renewable technologies is driving the energy sector towards achieving net-zero emissions. This shift is expected to have notable economic impacts, including the creation of new job opportunities and changes in energy production and consumption patterns across various sectors. Therefore, finding a suitable model to accurately measure and predict the diverse impacts of the energy transition on economies and the environment is an important challenge.

Top-down (TD) models have historically been used to evaluate the overall effects of climate change or government policies on the economy, such models represent economic agents in an aggregate manner. For example, they usually treat the entire electricity generation industry as a single sector, without considering the crucial differences between fuel-based and renewable generation technologies (Wing, 2006). In contrast, bottom-up (BU) models provide detailed information about specific sectors but may not capture the widespread effects of energy policies on the economy. Therefore, linking both types of models to improve the estimated economic and environmental impacts of energy transition scenarios has been an important topic in recent years.

The linking between these two kinds of models has been developed using two approaches: soft-linking and hard-linking (also known as hybrid models). Soft-linking involves implementing TD and BU models separately and feeding back the results of one model to the other in an iterative manner (Yang et al., 2021). Various studies have used this approach, using a Computable General Equilibrium (CGE) model as the TD model and other tools, such as TIMES (Timilsina et al., 2021) or LEAP (O'Ryan et al., 2020), as the BU model. Meanwhile, hybrid approaches integrate TD and BU into a single model (Cai, 2015) or execute them in cascade (Timilsina & Jorgensen, 2018), expanding one model with information fed from the other. Because these modelling approaches are generally CGE-based, their weaknesses include the large number of assumptions and parameters that must be adjusted (Garret, 2017). As an alternative, there are proposals for Input-Output Hybrid Equilibrium (IO-HE) models (Wing, 2008) (Lindner et al., 2013), enabling to capture economic interactions both at the macro and micro levels. Input-Output (IO) tables allow to systematically and coherently represent the structure and economic relations of a region or a country, considering its productive sector, income distribution, and consumption of goods and services. Social Accounting Matrices (SAMs) are a type of IO table used in economics to analyse the interdependence between different sectors in an economy, a SAM is a snapshot of the value flows in an economy in equilibrium at a particular point in time, usually used as TD model in IO-HE approaches. Regarding BD, this information can come from historical data and engineering models intended to represent the interactions between the many individual components of a sector with the rest of the economy.

The gap in the literature that this paper addresses is how to include energy storage and green hydrogen production into IO-HE models, which will be key as the energy sector decarbonizes. To address this problem, we conducted a pilot study using an IO-HE model that combines a TD SAM-based model from the Chilean government with BU data coming from an electricity generation model and information gathered from the hydrogen industry. Thus, we added a “Green Hydrogen” sector and disaggregated the “Electricity Generation” sector by technology. A challenge that must be addressed when expanding an economic sector or adding a new one is that the process introduces some inconsistencies between technical and economic data (Peters & Hertel, 2016), which require a calibration procedure to obtain accurate results. Thus, the contribution of this paper is to propose an approach to provide a novel calibrated SAM that quantifies each electricity technology impact on the economy, making it a powerful tool for policy-makers to evaluate the economic impacts of transitioning to a cleaner energy matrix.

2 METHODOLOGY

The main objective of the proposed IO-HE model is to expand the SAM developed by a government entity for a base year by adding a new "Green Hydrogen" sector and breaking down the "Electricity Generation" sector by technology. For this, we reconcile both TD and BU models through an adjustment and calibration process. The process ensures that the calibrated SAM aligns with the economic relationships established by the government entity (TD model) and with engineering data, inter-industry relationships, and observable values in the energy sector (BU model).

Fig. 1 presents a simplified structure of a SAM that represents an economy with Nx sectors, Nv primary factors, and Ng final consumption categories. The SAM comprises of three data matrices: an intermediate consumption matrix X, a factor payments matrix V, and a final consumption matrix G. The total input value of each sector (Yj) is the sum of its own production (i.e., Xj,j), intermediate inputs consumed from other sectors, and factor payments (e.g., labour, imports, and capital). The total output value of each sector (yi) is the sum of its own consumption (i.e., Xi,i), demand of intermediate inputs from other sectors, and demand of final consumption categories (e.g., household consumption and exports). In an economy in equilibrium, the total value of output and total value of input for each sector are equal, i.e., $yi=Yi$ for all i.

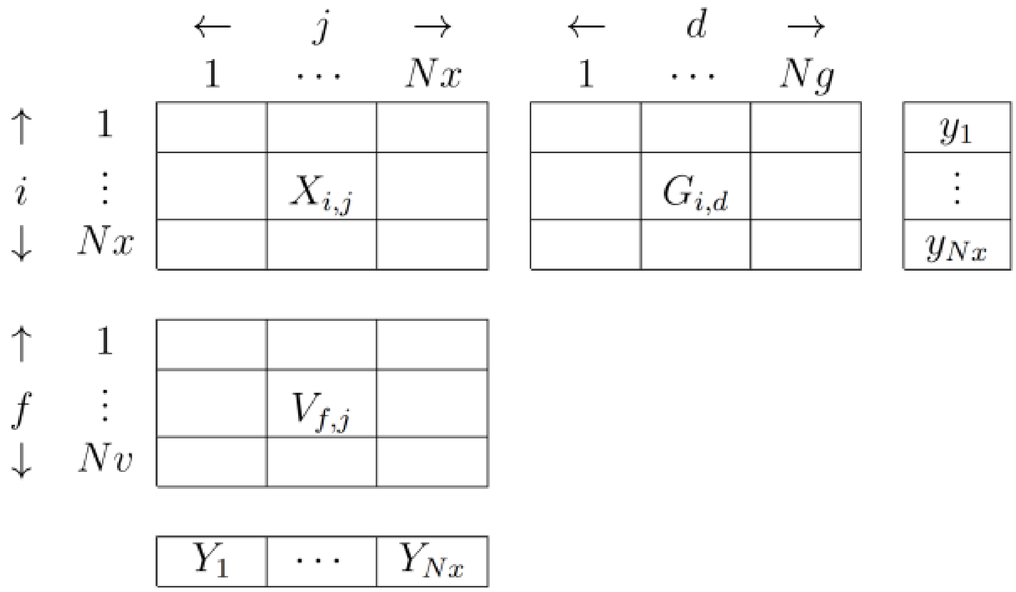


Figure 1. Diagram of the structure of a SAM

2.1 Breaking down the "Electricity Generation" sector

To ensure consistency between the TD SAM-based model and the BU electricity generation model, the latter must capture a snapshot of the energy sector at the same point in time. This means identifying the different technologies that make up the "Electricity Generation" sector, such as fuel-based, hydroelectricity, energy storage, solar, and wind generation plants. Historical data is then collected for each technology during the time frame of interest, such as installed capacity, injected energy, labour remuneration, and capital. This data comes from various Chilean entities, including the National Energy Commission, National Statistics Institute, and Central Bank.

To accurately represent the inter-sectoral consumption of the "Electricity Generation" sector in the IO-HE model, we distribute it among the different generation technologies. However, this task requires careful consideration of the relationships that each technology can sustain within the economy from both an economic and electrical engineering perspective. For example, in our specific case, the original SAM includes an "Oil and Gas Extraction" sector, and the “Electricity Generation” consumption of this sector is only attributed to diesel and natural gas generation plants. In the IO-HE model, this translates to a null consumption from the "Oil and Gas Extraction" sector for all other considered generation plants. Therefore, the consumption must be allocated between the diesel and natural gas generation plants. We assume that this consumption is divided proportionally between both technologies based on the collected data of injected energy. In the case of the disaggregated "Electricity Generation" consumption of labour and capital, these values are fixed in the IO-HE model by directly using the collected data for each considered technology. In our pilot study, for the "Electricity Generation" production break down, we assume that electricity consumption occurs regardless of the technology that supplies it. This means that sectors and final consumption categories do not deliberately decide to consume electricity from a particular technology.

Finally, to incorporate the self-production (self-consumption) of the "Electricity Generation" into our IO-HE model, we assume that generation technologies do not produce electricity for other technologies, except for energy storage. Thus, any production values in this regard are fixed at zero. The original self-production value is then divided proportionally among each technology's self-production values based on its installed capacity multiplied by an arbitrary value $0 \leq \omega \leq 1$, with the remaining production allocated to the storage technology proportional to the injected energy multiplied by $1 - \omega$.

2.2 Adding the “Green Hydrogen” sector

As “Green Hydrogen” is not already considered into the original SAM, an arbitrary total input and output value is assigned to this new sector, denoted as *yH*. This has been divided into two components: national production and exports, according to an adjustable allocation share $0 \leq \sigma \leq 1$. Then, the national production is allocated among other sectors and final consumption categories (excluding exports) in proportion to the production of the 'Electricity Generation' sector in the original SAM. We assume that the new “Green Hydrogen” sector does not produce for any generation technology, and thus the remaining production is assigned to exports according to the percentage indicated by σ. In the future, we intend to model the hydrogen supply chain in more detail.

To account for the consumption of "Green Hydrogen" across different sectors and technologies, relevant information regarding consumption patterns needs to be gathered. To this end, a survey has been designed to be completed by experts in the hydrogen industry. This survey seeks to gather data on the percentage of consumption for each sector based on their relationship with the industry, including self-production. Relationships involving sectors with zero consumption, such as the "Green Hydrogen" sector that does not consume from non-renewable technologies, must be fixed. Thus, the total input value for this new sector, *yH*, is then distributed proportionally among sectors and primary factors based on the percentage values collected from the survey.

2.3 Calibration process

To obtain a calibrated SAM that accurately reflects the economy, a calibration process is necessary to resolve any inconsistencies between the BU and TD models, aiming to satisfy: (i) representing an economy in equilibrium; (ii) maintaining the sum of the total output and input values of all generation technologies equal to the original “Electricity Generation” values; and (iii) keeping the total output and input values of all remaining sectors in the calibrated SAM equal to their values in the original SAM.

To accomplish this, a fractional error decision variable is introduced to all proportions for the allocation of consumption and production values among different technologies and the green hydrogen industry. The calibration process is an optimization program that minimizes the sum of the quadratic values of the fractional error decision variables, while ensuring that conditions (i), (ii), and (iii) are met. As a result, the calibrated SAM is consistent with the TD and BU models and can provide realistic projections and insights into the economic impact of incorporating the “Green Hydrogen” sector at different penetration levels, adjustable by *yH*. Additionally, it highlights the specific role played by each generation technology in shaping the economy.

3 RESULTS

To obtain preliminary results from our tool, we used the 2016 SAM issued by the Chilean Central Bank as the TD model. For the BU model, we collected historical data to define the consumption and production patterns of each generation technology and assigned a value of 0.5 to ω as explained in

Section 3.1. The data for the considered generation technologies in this numerical example are summarized in Table 1. In the future we intend to refine the parameters of our model.

Table 1. Information used for numerical example. Sources: *CNE Yearbook, **INE Electric Generation Survey, ***Central Bank, and ****Arbitrarily set.

Technology	Installed Capacity [MW]*	Injected Energy [GWh]*	Labour Remuneration [b$]**	Capital [b$]**	CO2 footprint [ton/MWh]***
Coal	4155	32456	56.65	184.31	5498
Gas	4125	11986	59.23	192.68	2883
Diesel	3345	1889	38.63	125.66	3808
Hydro reservoir	3341	7944	36.47	95.09	0
Hydro run-of-river	2776	11502	10.57	76.07	0
Mini-Hydro run-of-river (< 20 MW)	436	1913	1.76	12.68	0
Wind	1029	2252	0.72	6.75	0
Solar	1121	2550	0.57	260.59	0
Biomass	441	2643	0.38	0	5755
Energy Storage****	1000	1000	0.10	100	0

Concerning the BU model of the "Green Hydrogen" sector, we set the production level (*yH*) and exports share (σ) to 100 and 25, respectively, without any empirical basis. The consumption patterns of "Green Hydrogen" were modelled based on an arbitrary survey, presented in Table 2. This survey aims to gather information for the considered sectors under an arbitrary categorization.

Table 2. "Green Hydrogen" consumption survey used for numerical example, values in percentage.

Hydro reservoir	Hydro run-of-river	Wind	Solar	Services	Transport	Labour	Capital	Self-consumption	Others
8	4	27	31	2	5	10	10	1	2

Fig. 2 shows our main results for this numerical example, encompassing the total input and output values, Leontief multipliers, and the CO2 carbon footprint for the studied sectors. The distribution of input and output values across different generation technologies is complex and depends on multiple variables. For example, even though "Coal" triple the injected energy value of "Gas", its total input and output values are not even the double of "Gas". The "Green Hydrogen" sector has the highest Leontief multiplier value, even when it is compared with sectors of high national importance, such as "Wine Production" and "Copper Mining". This means that an increase in its demand results in the largest output increase across the economy. Meanwhile, the CO2 footprint is calculated based not only on a sector's own emissions, but also from the sectors from which it consumes. As a result, the calculated emissions align with each technology's production levels and direct and indirect emissions.

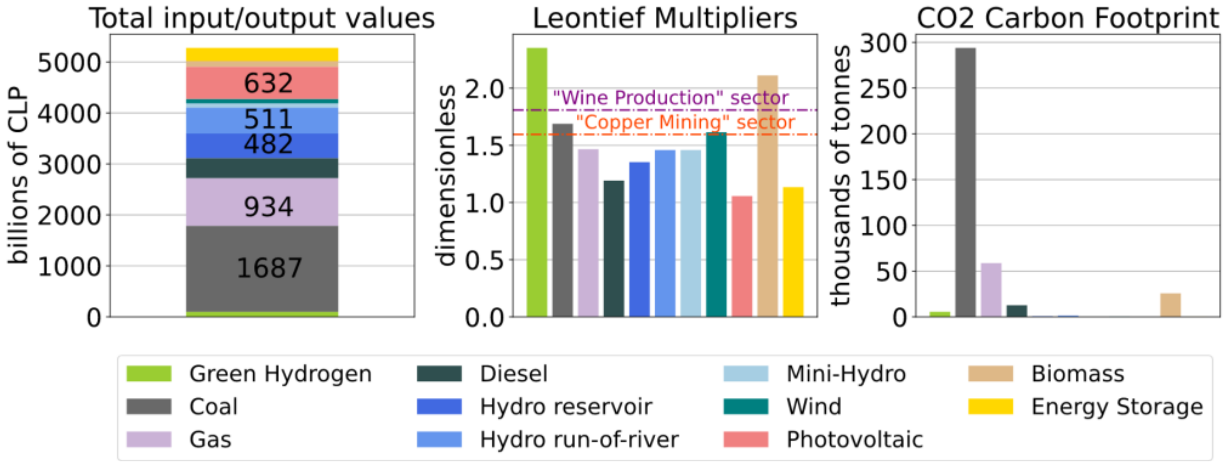


Figure 2. Main results from numerical example

4 CONCLUSIONS

Since the proposed IO-HE model is in a pilot stage, the presented results serve only to demonstrate the capabilities of our approach and require further refinement before any definitive conclusions can be drawn. Our results demonstrate the potential of the developed tool to inform policy-makers about the potential effects of the green hydrogen industry in the Chilean economy. Our approach could also be applied to evaluate the economic impacts of the energy transition in other countries or regions.

In further work, significant efforts will be undertaken to enhance the proposed model, including the development of an Operation Simulation Model (OSM) that would accurately simulate the operation of the electric power system for a calendar year. The OSM has the potential to generate results for different scenarios that can be used by the IO-HE model, such as energy generated by technology and specific economy sector consumption from each technology, as well as other outcomes aiming to provide a better understanding of the energy sector. We will rely on the OSM to accurately address the future consequences of the energy transition, as it is key to obtain a high-quality representation of the energy sector under different generation portfolios aiming to achieve net-zero emissions.

5 ACKNOWLEDGEMENTS

This work was supported by ANID through grants FONDEF ID22I10341 and FB0008 (Advanced Center for Electrical and Electronic Engineering, AC3E).

REFERENCES

Cai, Y., Newth, D., Finnigan, J., & Gunasekera, D. (2015). A hybrid energy-economy model for global integrated assessment of climate change, carbon mitigation and energy transformation. *Applied Energy*, *148*, 381-395. https://doi.org/10.1016/j.apenergy.2015.03.106

Garrett-Peltier, H. (2017). Green versus brown: Comparing the employment impacts of energy efficiency, renewable energy, and fossil fuels using an input-output model. *Economic Modelling*, *61*, 439-447. https://doi.org/10.1016/j.econmod.2016.11.012

Lindner, S., Legault, J., & Guan, D. (2013). Disaggregating the electricity sector of China's input–output table for improved environmental life-cycle assessment. *Economic Systems Research*, *25*(3), 300-320. https://doi.org/10.1080/09535314.2012.746646

O'Ryan, R., Nasirov, S., & Álvarez-Espinosa, A. (2020). Renewable energy expansion in the Chilean power market: A dynamic general equilibrium modeling approach to determine CO2 emission baselines. *Journal of Cleaner Production*, *247*, 119645. https://doi.org/10.1016/j.jclepro.2019.119645

Peters, J. C., & Hertel, T. W. (2016). The database–modeling nexus in integrated assessment modeling of electric power generation. *Energy Economics*, *56*, 107-116. https://doi.org/10.1016/j.eneco.2016.03.004

Timilsina, G. R., Pang, J., & Xi, Y. (2021). Enhancing the quality of climate policy analysis in China: Linking bottom-up and top-down models. *Renewable and Sustainable Energy Reviews*, *151*, 111551. https://doi.org/10.1016/j.rser.2021.111551

Timilsina, G., & Jorgensen, E. (2018). The economics of greening Romania's energy supply system. *Mitigation and adaptation strategies for global change*, *23*, 123-144. https://doi.org/10.1007/s11027-016-9733-9

Wing, I. S. (2006). The synthesis of bottom-up and top-down approaches to climate policy modeling: Electric power technologies and the cost of limiting US CO2 emissions. *Energy Policy*, *34*(18), 3847-3869. https://doi.org/10.1016/j.enpol.2005.08.027

Wing, I. S. (2008). The synthesis of bottom-up and top-down approaches to climate policy modeling: Electric power technology detail in a social accounting framework. *Energy Economics*, *30*(2), 547-573. https://doi.org/10.1016/j.eneco.2006.06.004

Yang, X., Pang, J., Teng, F., Gong, R., & Springer, C. (2021). The environmental co-benefit and economic impact of China's low-carbon pathways: Evidence from linking bottom-up and top-down models. *Renewable and Sustainable Energy Reviews*, *136*, 110438. https://doi.org/10.1016/j.rser.2020.110438

RENEWABLE ENERGIES INVESTMENT IN EUROPEAN COUNTRIES – THE CASE OF PORTUGAL (SOLAR AND WIND)

Max López-Maciel[1], Edimar Ramalho[2]; Mara Madaleno[2,3]; José Villar[4]; André de Oliveira[4], Marta Ferreira Dias[2,3]; Anabela Botelho[2,3]; Margarita Robaina[2,3]

[1]CESAM & Department of Environment & Planning, Aveiro University (DAO-UA), Portugal
[2]Research Unit on Governance, Competitiveness and Public Policies (GOVCOPP)
[3]DEGEIT, University of Aveiro, Campus Universitário de Santiago, Portugal
[4] Centre for Power and Energy Systems, INESC TEC, Campus da FEUP, Rua Dr Roberto Frias, 4200-465 Porto, Portugal

Abstract

The transition towards renewable energies has become a global priority in the fight against climate change, and many countries have been investing heavily in this sector. Portugal, in particular, has been a key player in Europe for the development of renewable energy projects.

This paper aims to provide an overview of the investment opportunities in renewable energy in Portugal.

The Portuguese government has set ambitious targets for the development of renewable energy, aiming for 80% of its electricity to come from renewable sources before 2030. This can create a favorable business environment for renewable energy investors, with a range of incentives and tax breaks available to encourage investment. Furthermore, Portugal's location on the Atlantic coast provides an ideal environment for the development of offshore wind farms.

The paper will provide an analysis of the various renewable energy projects currently underway in Portugal, highlighting key players in the industry and the potential for future investment. It will also explore the challenges facing renewable energy investment in Portugal.

Keywords: Renewable Energy; Wind Energy; Solar Energy; Climate Change; Portugal.

1. Long Abstract

This paper aims to provide a comprehensive overview of the investment opportunities in renewable energy in Portugal, with a focus on solar and wind projects. The transition towards renewable energies has become a global priority in the fight against climate change, and Portugal has been a key player in Europe for the development of renewable energy projects. The Portuguese government has set ambitious targets for the development of renewable energy, with a goal of having 80% of its electricity generated from renewable sources by 2030. This creates a favorable business environment for renewable energy investors, with a range of incentives and tax breaks available to encourage investment.

One of Portugal's strengths for renewable energy is its location on the Atlantic coast, which provides ideal conditions for the development of offshore wind farms. Portugal has already made significant progress towards achieving its renewable energy targets, with a variety of solar and wind projects currently underway. In 2020, renewable energy sources represented 56% of the country's electricity production, which demonstrates Portugal's strong commitment to renewable energy.

The paper analyzes the various renewable energy projects currently underway in Portugal, highlighting key players in the industry and the potential for future investment. The analysis includes the main technical characteristics of these projects, such as capacity and location. Moreover, the paper explores the challenges facing renewable energy investment in Portugal.

For this purpose, the Portuguese government approved the Plano Nacional Energia e Clima 2030 (PNEC 2030) in compliance with the obligations established by the Regulation on the Governance of the Energy

Union and Climate Action (Regulation (EU) No. 2018/1999 of 11 December 2018). According to Energia em Números - Edição 2022, published in June 2022, the document provides statistical data on the main national energy indicators, particularly focusing on information for 2019 and 2020, and is an essential tool for promoting energy literacy. The publication shows that Portugal is less dependent on external energy sources than it was in 2010, with a dependence rate of 65.8% in 2020, down from 76.1% in 2010. The goal of the national energy policy is to reduce this dependence to 65% by 2030, as established in the PNEC. In 2020, Portugal was the 11th country in the European Union with the highest energy dependency rate, 7.8 percentage.

The Plano Nacional Energia e Clima 2030 (PNEC 2030) sets ambitious yet achievable targets for reducing greenhouse gas emissions (45% to 55% compared to 2005), increasing renewable energy production (47%), improving energy efficiency (35%), increasing interconnections (15%), enhancing energy security, developing the internal energy market, and promoting research, innovation, and competitiveness. Additionally, the PNEC 2030 establishes sector-specific targets for reducing greenhouse gas emissions, including a 70% reduction in emissions in the services sector, 35% in the residential sector, 40% in the transportation sector, 11% in the agriculture sector, and 30% in the waste and wastewater sector.

The implementation, coordination, and future revisions of the PNEC 2030 are the responsibility of the Grupo de Coordenação do PNEC 2030, co-coordinated by the Portuguese Environment Agency and the Directorate-General for Energy and Geology, in collaboration with the entities provided for in the National System of Policies and Measures. The plan facilitates the coordination of the national contribution to fulfilling community and international commitments and facilitates the execution of policy guidelines outlined in the plan or mandated by the Commission for Climate Action (CAC).

In Portugal, there are several key players in the renewable energy industry who are driving the country's energy transition Like EDP.LS, IberBlue Wind and Iberdrola.

For instance, EDP, has announced its plan to invest 25 billion euros over four years to nearly double its renewable energy capacity to 33 GW by 2026. EDP Renovaveis, the company's wind and solar unit and the world's fourth-largest renewable energy producer, will invest 21 billion euros, while the remaining 4 billion euros will be directed towards electricity grids. The company aims to increase average annual investment to 6.2 billion euros, 30% more than the previous plan that ran until 2025. EDP said the investment plan demonstrates its commitment to the energy transition, with a focus on onshore wind and solar, and a smaller investment in offshore wind, batteries, and hydrogen. As of December 2020, EDP had installed capacity of 18 GW.

For wind energy, IberBlue Wind, an Irish-Spanish consortium, has announced plans to invest more than 4 billion euros in two wind farms off the Atlantic coasts of Portugal and Spain. The two parks, called Creoula and Juan Sebastian Elcano, are expected to have a combined installed capacity of 1.96 GW, with approximately 109 turbines occupying an area of 530 square km. The larger Creoula park will have 80 turbines, each with 18 MW capacity. The project will contribute to Portugal's goal of installing 10 GW of offshore wind by 2030, and will provide enough electricity to power over one million homes.

For solar energy, one of the major players in Portugal include Iberdrola, which along and the European Investment Bank (EIB) have signed a €70 million green loan agreement to speed up the transition to renewable energy in Portugal. The funding will be used to construct a portfolio of five solar PV plants with a total capacity of approximately 188 MW. These projects will produce green and competitive energy equivalent to the average consumption of more than 65,000 households, and will contribute to the European Union's security of energy supply, climate action, and social cohesion plans. The facilities, will mainly be located in rural areas of Portugal, considered cohesion regions by the EU. The investment will also cover infrastructure, such as access roads, substations, and interconnections. The new infrastructure is expected to create around 1,000 direct jobs during the construction phase and generate economic growth and employment in the region.

Despite the significant investments made by these key players in renewable energy in Portugal, there are still challenges that need to be addressed.

The International Energy Agency (IEA, 2021) also suggests that the government of Portugal should establish a broad stakeholder alliance to drive rapid implementation of the measures in the Roadmap for

Carbon Neutrality, the National Energy and Climate Plan and the National Hydrogen Strategy. This will not only help in achieving carbon neutrality, but also provide investor certainty on policy direction. This alliance should include representatives from various sectors such as industry, finance, civil society, and academia.

In addition, the IEA recommends that the government of Portugal should accelerate the reform to align energy taxes with decarbonisation goals. This will help ensure that the carbon tax drives emissions reductions in all sectors. The government should also enhance electricity retail market competition by removing barriers to entry for new players and facilitate market innovation to incentivize demand response, distributed renewables and increased electrification while ensuring market integrity and security.

Furthermore, the government of Portugal should prioritize the deep renovation of public buildings and residences owned or rented by vulnerable consumers in order to reduce energy poverty, increase thermal comfort, and support the achievement of decarbonisation goals. This will not only reduce carbon emissions but also help vulnerable consumers save money on their energy bills.

REFERENCES

Agencia portuguesa do ambiente. (n.d.). Plano Nacional de Energia e Clima (PNEC) | Agência Portuguesa do Ambiente. Retrieved May 3, 2023, from https://apambiente.pt/clima/plano-nacional-de-energia-e-clima-pnec

Direçao Geral de Energia e Geología. (2022). Energia em Números, edição 2022. Retrieved May 3, 2023, from https://www.dgeg.gov.pt/pt/destaques/energia-em-numeros-edicao-2022/

EIB finances our first solar plants in Portugal. (2022). Iberdrola. Retrieved May 3, 2023, from https://www.iberdrola.com/press-room/news/detail/eib-finances-our-first-solar-plants-in-portugal

Goncalves, S. (2023, April 11). IberBlue Wind to invest $4.36 bln in Portugal-Spain offshore wind. *Reuters*. https://www.reuters.com/business/energy/iberblue-wind-invest-436-bln-portugal-spain-offshore-wind-2023-04-11/

Goncalves, S., Chestney, N., & Chestney, N. (2023, March 2). Portugal's EDP to invest $27 billion to nearly double renewable capacity. Reuters. https://www.reuters.com/business/sustainable-business/portugals-edpr-invest-2234-billion-until-2026-push-green-growth-2023-03-02/

International Energy Agency. (2021). Portugal 2021 – Analysis - IEA. Retrieved May 3, 2023, from https://www.iea.org/reports/portugal-2021

Portugal bets all on renewables after abandoning coal. (2022, October 17). France 24. https://www.france24.com/en/live-news/20221017-portugal-bets-all-on-renewables-after-abandoning-coal

Scientific Parallel Sessions 2:

A- Energy efficiency, renewables and sustainability *(hybrid)*

Chair: Marta Ferreira Dias

link: https://videoconf-colibri.zoom.us/j/91547292878 ; room: 10.2.2

- DO SUSTAINABILITY AND GREEN PRACTICES REDUCE COSTS IN THE PORK SUPPLY CHAIN
  Sebastiano Bacca, Rita Sousa, Daniela Campos *(presencial)*
- A GLOBAL REVIEW OF SUSTAINABILITY REPORTING IN THE ENERGY SECTOR
  Connor Guilherme, Patrícia Pereira da Silva and Susana Jorge *(presencial)*
- ENERGY EFFICIENCY IMPROVEMENTS IN A PORTUGUESE CERAMIC INDUSTRY: CASE STUDY
  Susana Carvalheira, Miguel Oliveira, Margarita Robaina, João C. O. Matias *(online)*
- CHARACTERIZATION OF THE ECONOMIC, ENVIRONMENTAL, AND SOCIAL IMPACTS OF RENEWABLE ENERGIES Edimar Ramalho; Max López-Maciel; Mara Madaleno; José Villar; Marta Ferreira Dias; Anabela Botelho; Margarita Robaina *(presencial)*
- RENEWABLE ENERGY COMMUNITIES: CONCEPTS, APPROACHES AND THE CASE STUDY OF TELHEIRAS NEIGHBORHOOD IN LISBON
  Evandro Ferreira, João Pedro Gouveia, Miguel Macias Sequeira *(online)*
- CONSUMERS SWITCHING INTENTION AMONG ELECTRICITY SUPPLIERS: A PUSH-PULL-MOORING MODEL
  Fábio Vieira, Mónica Meireles, Graça Trindade *(online)*

B- Energy Poverty *(online)*

Chair: Mara Madaleno

link: https://videoconf-colibri.zoom.us/j/94079183124?pwd=Q00zWU0xYk5WY25vQW53OTMrK1JLZz09
room: 10.1.16

- AN ASSESMENT OF FUEL POVERTY IN TROPICAL TERRITORY: CASE OF LA REUNION
  Manitra Rakotomena, Olivia Ricci
- ANALYSIS OF FINANCING SCHEMES TARGETING ENERGY EFFICIENCY AND ENERGY POVERTY MITIGATION IN THE EUROPEAN UNION, UK, AUSTRALIA AND NEW ZEALAND
  Bárbara Fernandes, João Pedro Gouveia
- EXPLORING ENERGY POVERTY AND THERMAL COMFORT IN UPPER SECONDARY STUDENTS: A CASE STUDY OF LISBON, PORTUGAL
  Inês Valente, João Pedro Gouveia
- STUDENTS' PERCEPTION OF ENERGY POVERTY— COMPARATIVE ANALYSIS AMONG CITIES IN DIFFERENT COUNTRIES AND AMONG REGIONS IN PORTUGAL
  Carolina Cruz Castro, João Pedro Gouveia
- PORTUGUESE DWELLINGS ACCESS TO MOBILITY IN AN EVERGROWING ENERGY VULNERABLE REALITY
  João Bodião, João Pedro Gouveia
- ENERGY POVERTY ADVISORY HUB: SUPPORTING ENERGY POVERTY DIAGNOSIS THROUGH INDICATORS SELECTION, Salomé Bessa, João Pedro Gouveia, Pedro Palma, Katherine Mahoney, Miguel Sequeira

DO SUSTAINABILITY AND GREEN PRACTICES REDUCE COSTS IN THE PORK SUPPLY CHAIN

Sebastiano Bacca[1], Rita Sousa[2], Daniela Campos[3]

[1] *NIPE and School of Economics and Management, University of Minho, Braga, Portugal, sebastiano.bacca@gmail.com*

[2] *NIPE and School of Economics and Management, University of Minho, Braga, Portugal, ritasousa@eeg.uminho.pt*

[3] *School of Economics and Management, University of Minho, Braga, Portugal, fatimacampos99@gmail.com*

Keywords: Supply Chain Responsibility, Sustainability, Green practices, Pork supply chain.

Extended Abstract

Sustainability is imperative for the food supply chain since animal products contribute to approximately 50% of the total greenhouse gas (GHG) emissions generated by food production. Corporate Social Responsibility (CSR) philosophy and Supply Chain Responsibility (SCR) drive environmentally friendly practices, and Short Food Supply Chains (SFSCs) have arisen as a sustainable alternative. Although concerns about environmental sustainability are recent, they are increasingly important to consumers, producers, distributors, and retailers. The present study aims to investigate sustainability indicators and socially responsible organizational behaviour, as well as the role of retailers. Green supply chain management practices, such as reducing waste and improving environmental sourcing, can enhance organizational performance and reputation. However, the overall impact of such practices on business sustainability is still not well-understood. Using a relevant case study, this paper assesses whether there exists a positive correlation between a sustainable food supply chain that adopts green practices and efficiency in terms of cost reduction, with a focus on the pork supply chain among retailers in Northern Portugal. In this country, fresh meat is preferred, and retail services that commercialize pork meat are significant job creators, representing 6.7% of Portuguese agri-food exports. The study was conducted in some municipalities in the north of the country, including 57 companies (supermarkets, retailers, and butcheries), since this sector is complex and dominated by small-sized operators.

Initially, this study examined the literature on sustainability in supply chains, specifically focusing on pork supply chains. Then, a survey was conducted consisting of 46 items designed to measure dimensions of mode, space, and time. 13 variables were initially created, including costs, strategic alliance with suppliers, customer relationship management, information sharing, trust, commitment, green practices, seniority, dimension, and type of retailer. The analysis is conducted with a linear regression, and we test the hypothesis that greener supply chains are also more efficient. A stepwise mixed procedure regression function was used to select the best option, resulting in a final model for analysis.

The study has led to clear conclusions regarding the relationship between costs and some sustainable practices, as well as less clear conclusions regarding the effects of strategic alliances.

We found a positive relation between cost levels and the variables that explain the relationship between suppliers and the green energy practices adoption, meaning that increasing the level of those practices correspond to an increase in costs and hence an efficiency loss. Opposingly, the variables information sharing, client relationship management and water green practices adoption showed negative coefficients highlighting an inverse relationship between cost levels and those dimensions, thus, if the latter variables increase in value, then there is a gain in efficiency for the company.

The study reveals that green practices related to water management play a vital role in determining the efficiency of supply chains. Although green practices associated with emissions and supplier partnerships can increase costs due to investment in renewable energy and efficiency measures effective customer relationship management, and sustainable water practices may decrease costs and enhance efficiency. Although the green practices related to waste management are not statistically significant, they resulted in a negative coefficient meaning that waste reduction initiatives, particularly in the food industry where enormous amounts of food waste are generated, can help lower perceived costs. In conclusion, we emphasize the importance of minimizing meat wastage and utilizing leftovers for the production of derived products to avoid food waste costs.

The size of the companies in the study did not prove to be a statistically significant variable, and further research is needed to understand the sustainability implications of shorter supply chains.
Larger companies show greater concern for environmentally friendly practices and are more willing to make investments in this respect, which highlights their higher awareness and sense of social responsibility. Retailers may also have a determinant role in directing consumers to more sustainable choices through their own supply and promotion of more sustainable products.
In summary, the research indicates that adopting sustainable water practices, along with investment in customer relationship management and information sharing, can enhance the efficiency and sustainability of supply chains. However, further research is required to evaluate the impact of emissions on supply chain efficiency. This study is subject to limitations, including the absence of quantitative measurements and external factors that may affect the outcomes. Future research should consider additional variables and involve organizations at various stages of the chain. The findings emphasize the importance of green practices for effective business management and sustainable development. As such, this study presents significant insights into the efficiency and sustainability of pork supply chains and the potential benefits of implementing green practices.

REFERENCES

Bloemhof, J. M., van der Vorst, J. G., Bastl, M., & Allaoui, H. J. (2015). Sustainability assessment of food chain logistics. International Journal of Logistics Research and Applications, 18(2), 101-117.
Chkanikova, O., & Mont, O. (2015). Corporate supply chain responsibility: drivers and barriers for sustainable food retailing. Corporate Social Responsibility and Environmental Management, 22(2), 65-82.
Jie, F., & Gengatharen, D. (2019). Australian food retail supply chain analysis. Business Process Management Journal, Vol. 25 No. 2, pp. 271-287.
MacCarthy, B. L., Blome, C., Olhager, J., Srai, J. S., & Zhao, X. (2016). Supply chain evolution – theory, concepts and science. International Journal of Operations & Production Management, 36(12), 1696-1718.
Perez, C., de Castro, R., & i Furnols, M. F. (2009). The pork industry: a supply chain perspective. British Food Journal.
Petit, G., Sablayrolles, C., & Yannou-Le Bris, G. (2018). Combining eco-social and environmental indicators to assess the sustainability performance of a food value chain: A case study. Journal of Cleaner production, 191, 135-143.
Trienekens, J., & Wognum, N. (2013). Requirements of supply chain management in differentiating European pork chains. Meat science, 95(3), 719-726.

A GLOBAL REVIEW OF SUSTAINABILITY REPORTING IN THE ENERGY SECTOR

Connor Guilherme[1], Patrícia Pereira da Silva[1,2,3] and Susana Jorge[4,5]

[1]Energy for Sustainability Initiative University of Coimbra (PORTUGAL), connor.guilherme@student.uc.pt
[2]INESC Coimbra & Electrical and Computer Engineering Department (DEEC) University of Coimbra (PORTUGAL), patsilva@fe.uc.pt
[3]CeBER & Faculty of Economics University of Coimbra (PORTUGAL), patsilva@fe.uc.pt
[4]Faculty of Economics University of Coimbra (PORTUGAL), susjor@fe.uc.pt
[5]Research Centre in Political Science (CICP) University of Minho (PORTUGAL), susjor@fe.uc.pt

Abstract

The purpose of this paper is to compile the literature that has analyzed non-financial reports in the energy sector in order to identify areas that future research should prioritize. This study conducts a systematic process to identify relevant literature. 55 articles that analyze non-financial reports published by energy sector firms were identified and reviewed. This research finds that there is very little literature on non-financial reporting in the energy sector and that the literature is spread across subsectors and geography. It is found that Europe is the most studied region and that the field of accounting research is disconnected from the state of the art. The most common methods and theoretical frameworks across the literature are identified along with the most prominent researchers in this field of study. To the author's best knowledge, this research represents the first synthesis of global literature on non-financial reporting across the subsectors of the energy sector.

Keywords: energy sector, non-financial reporting, sustainability reporting, Environmental Social Governance (ESG) reporting, integrated reporting

1. INTRODUCTION

Sustainability reporting (SR) is becoming increasingly mandatory for firms globally. In the EU, in January 2023, the Corporate Sustainability Reporting Directive (CSRD) was passed into law; effectively formalizing the transition from voluntary SR to mandatory SR (European Commission, 2023). Globally, the International Sustainability Standards Board (ISSB) has announced that its initial standards will be officially released in Q2 2023 for regulators to then adopt at the national level (IFRS, 2023). With this wave of mandatory SR on the horizon globally, more research is needed to understand the consequences on all industry sectors. As all industries require energy at some level, the quality of SR disclosures by companies in the energy sector is critically important to the integrity of SR by companies in all other sectors. To date, there has been very little academic research completed in the field of SR with specific attention to the energy sector. With this in mind, the main goal of this paper is to compile the research that has analyzed SR in the energy sector in order to determine priority areas for future research.

2. METHODOLOGY

Figure 1 shows the 6-step approach taken to identify the relevant research on non-financial reporting in the energy sector. A broad search (Step 1) that covers all identified non-financial reporting related terms was completed in the SCOPUS and Web of Science databases. This broad search was narrowed by adding search terms related to the energy sector (Step 2). Abstracts of all resulting articles were then manually reviewed to determine whether they were related to non-financial reporting in the energy sector (Step 3). The articles were analyzed (Step 4) and classified into two groups (Step 5) before further discussion and conclusions were made (Step 6).

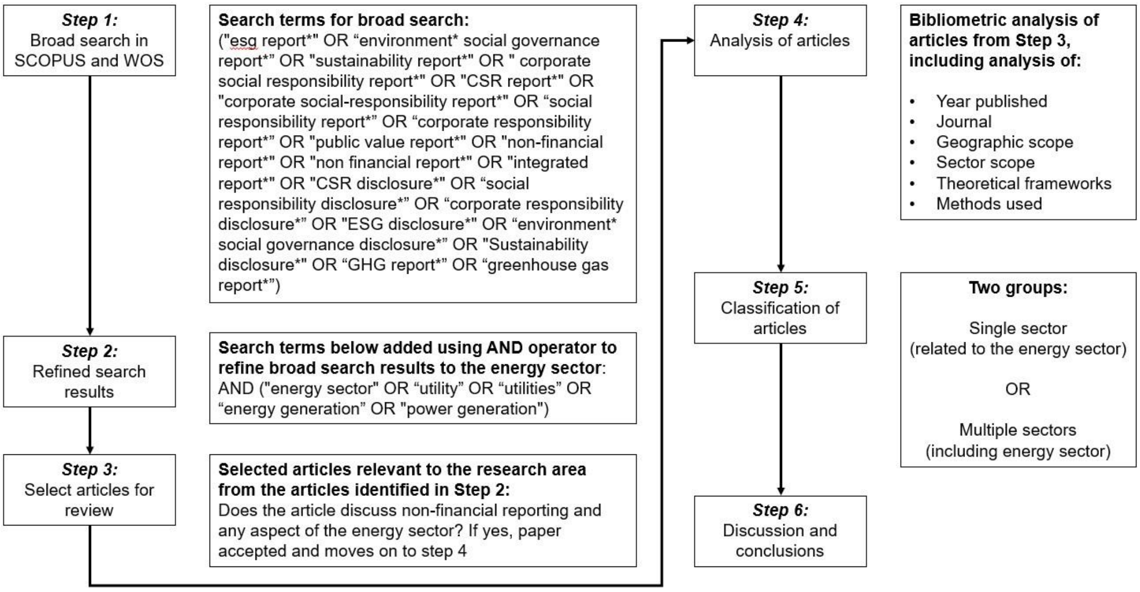


Figure 1. Systematic literature review process

3. RESULTS

Step 1 resulted in 6,346 articles. When the energy sector related search terms were added in Step 2, the number of articles was reduced to 142. Only journal articles written in English were considered. The abstracts of these articles were reviewed to determine which articles were relevant to the scope of this research (Step 3). This resulted in the identification of 83 articles. While these 83 articles moved on to Step 4, this paper focusses on the 55 articles within this group of 83 that specifically analyze non-financial reports published by the energy sector (See appendix for the list of the 55 articles). The term 'non-financial reporting' was purposely used here as it encapsulates numerous terms including: sustainability reporting, environmental social governance (ESG) reporting, corporate social responsibility (CSR) reporting and integrated reporting (<IR>). While the CSRD, ISSB and the Global Reporting Initiative (GRI) all use the term 'sustainability reporting,' use of this term across industry and academia is common but not consistent and <IR> is the integration of financial *and* sustainability reporting (IFRS, 2021). Results for the analysis of the 55 articles are presented in two figures. Figure 2 shows the number of articles published by each journal listed along with corresponding SJR indicator scores for each respective journal. Figure 3 shows the country or region that the article focusses on as well as whether the articles focus on a single sector or multiple sectors.

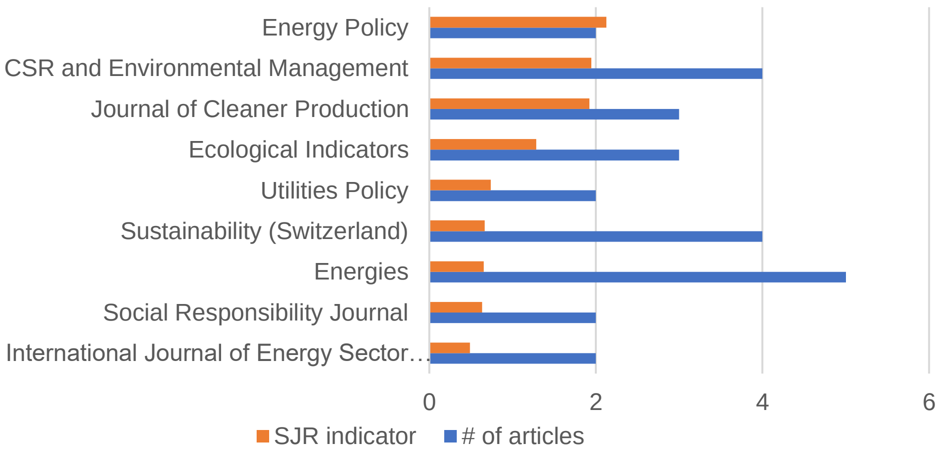


Figure 2. Number of articles from each journal and corresponding SJR score. Only journals with more than one of the 55 articles are listed.

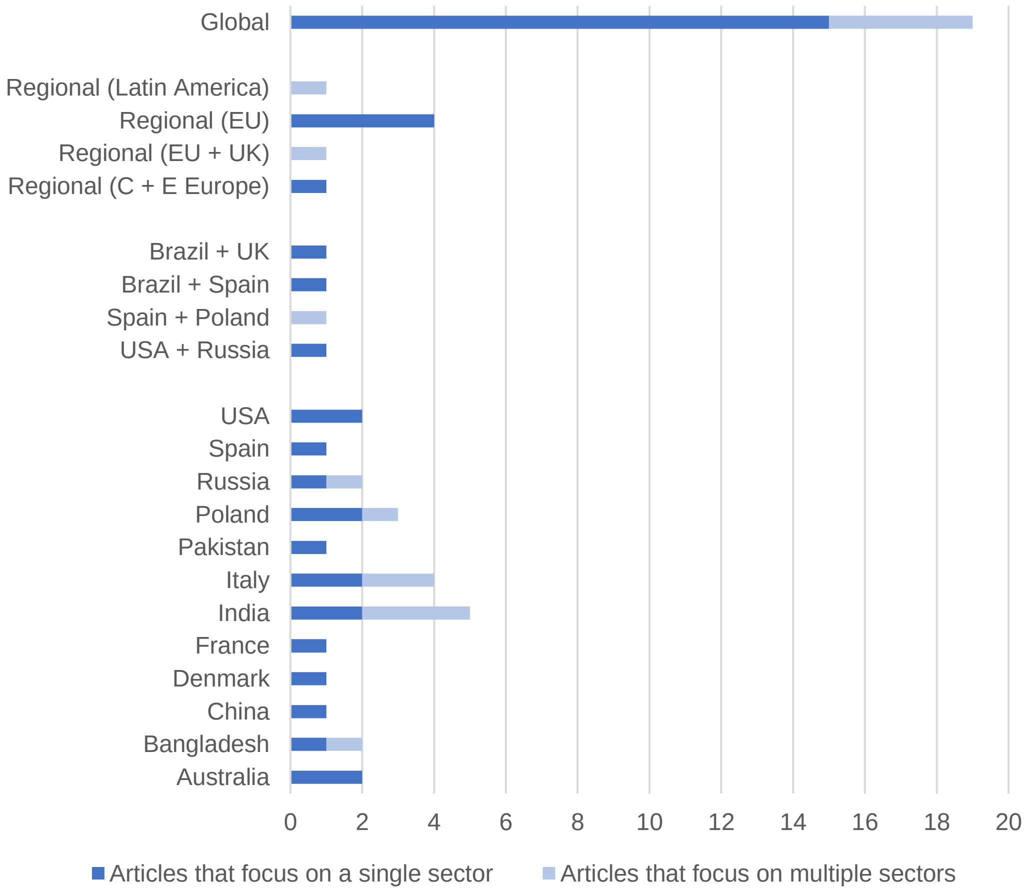


Figure 3. Number of articles that specifically focus on analyzing non-financial reports in the energy sector in each country or geographic region. Articles that compare non-financial reporting in two countries (e.g., Brazil + UK) are tallied. Articles that analyze regions (e.g., C + E = Central and Eastern) are tallied. Articles that analyze more than two countries and were not of a regional focus are categorized as global. Based on the 55 articles resulting from the specific search in step 3 of Figure 1.

4. DISCUSSION

The first observation that should be made is the fact that there is very little research in this area as only 55 articles were identified. The 55 articles identified were published between 2010 and 2023, while 43 of the articles (78%) were published during or after 2019. While research in this field is growing, the scope of the research is spread across geography. Figure 3 shows that, with 19 articles, the global scope grouping has more research than any single country or region. However, if all studies that consider European regions, European country comparison or a single European country are summed, the number of articles is 17 (Denmark, France, Italy, Poland, Spain, Spain + Poland, and the three regional groups). Thus, it is found that Europe is the most focussed on region with regards to research on non-financial reporting in the energy sector. In comparison to Europe's 17 articles, Asia is represented by 9 articles (Bangladesh, China, India and Pakistan) and North America is represented by 3 articles (USA, and USA + Russia). Notably, with 5 articles, India is the single country with the most articles followed by Italy with 4 articles. As Europe has been on the forefront of SR, it could be considered expected that more research on this topic would be focussed on the European context. As mandatory SR is soon to be established in other jurisdictions, this finding highlights the gap in the research across the world. While mandatory reporting is already in place in Europe it is perhaps surprising that there is not more literature on SR in the energy sector given the implications of the energy sector on all industrial sectors. As the energy sector is integral to all economies, attention should be placed on the countries that are not listed in Figure 3.

With regards to the scope of the articles, 34 articles (62%) focus on a single sector, however there was a wide variation of the exact focus across the research. Within the 34 articles that focus on a single sector, 22 articles focus on the energy sector, 5 articles focus on the oil & gas sector, 4 articles focus on electric utilities, 1 article focuses on electricity retailers, 1 article focuses on biomass firms and 1 article focuses on nuclear power generation. The remaining 21 articles (38%) focussed on multiple sectors. At least one of the multiple sectors considered was related to the energy sector. Within the 21 articles that focus on multiple sectors, 12 articles focus on multiple sectors including the energy sector, 6 articles focus on the utilities sector (including energy utilities sector), 1 article focuses on multiple sectors including the utilities sector (including energy utilities sector), 1 article focuses on the energy and banking sectors and 1 article focuses on the energy and mining sectors. Of the 22 articles that focus solely on the energy sector, the purposes and scopes vary widely. Alhawaj et al. found that there is a significant relationship between ESG disclosure level and operational performance but no significance in the relationship between ESG disclosure level and financial performance (Alhawaj, Buallay, & Abdallhah, 2022). In another article it was found that the level of disclosure related to action on achieving the sustainable development goals (SDGs) was inadequate by 105 global energy sector firms (Tsalis, Terzaki, Koulouriotis, Tsagarakis, & Nikolaou, 2022). In an article investigating circular economy (CE) and GHG emissions related disclosures in EU energy sector firms, it was found that CE actions to reduce GHG emissions are rarely found in sustainability reports (Janik, Ryszko, & Szafraniec, 2020). Similarly to the 22 articles that focus solely on the energy sector, the 12 articles that focus on multiple sectors including the energy sector also vary widely in the exact research focus. In a study focussed on the global diffusion of GRI-based SR, it was found that ‘Energy + Utilities’ consistently rank as the sector that most widely use the GRI standards (Del Mar Alonso-Almeida, Llach, & Marimon, 2014). Skouloudis et al. found that the energy sector was one of the global sectors that most commonly reports on biodiversity indicators (Skouloudis, Malesios, & Dimitrakopoulos, 2019). Through studying sustainability reports published by 237 companies across industry sectors in Italy it was found that reporting completeness is not correlated with better environmental performance (Calabrese, Costa, Levialdi, Menichini, & Montalvan, 2020).

These findings show that the “energy sector” consists of numerous subsectors and that non-financial reporting research has covered many of these subsectors. Not only does this research cover multiple subsectors, it is also clearly multidisciplinary as shown by the variety of journals that published the 55 articles. Figure 2 shows that policy, energy, management, social responsibility and ecologically focussed journals have all published articles in this research field. The journal with the most published articles is MDPI’s *Energies* journal with 5 articles, while the journal with the highest SJR indicator score is Elsevier’s *Energy Policy* journal with a score of 2.126. Notably, no accounting-based journals are present in Figure 2. This is an interesting finding that suggests that there is a disconnect between the field of research in accounting and the field of research in non-financial reporting. As non-financial reports are commonly assured by accounting firms this is an apparent research gap.

In terms of the theoretical frameworks used across the literature reviewed, this research finds that stakeholder theory and legitimacy theory are the two most prominent theoretical frameworks. This research also finds that agency theory, institutional theory, signalling theory, strategic stakeholder theory, resource-based value theory, neo-institutional theory and grounded theory are all also commonly discussed in the literature. In their 2020 research, Slacik & Greiling compiled a literature review section that lists the theoretical frameworks used across 22 articles that focus on SR by electric utilities (Slacik & Greiling, 2020b). All of the theoretical frameworks identified by Slacik & Greiling in this article are mentioned in the identified list above except for resource-based value theory and grounded theory. This close match suggests that the theoretical frameworks used in research on SR by electric utilities well represents the theoretical frameworks used by research on non-financial reporting in the energy sector at a broader level.

The majority of the 55 articles took a quantitative content analysis-based approach in studying non-financial reports. A common method used to analyze the selected non-financial statements was a mixed method content analysis approach that relied heavily on quantitative statistical analysis. In this approach, researchers extract information from non-financial reports through a qualitative process or by identifying qualitative groups then quantitatively study the results through statistical analyses (Ilysheva, Karanina, Baldesku, & Zakirov, 2017; Imperiale, Pizzi, & Lippolis, 2023; Janik et al., 2020; Piesiewicz, Ciechan-Kujawa, & Kufel, 2021). The level of statistical analyses varied widely from simple descriptive statistics to more complex statistical analyses, for example, using regression models to test for significant relationships between independent and dependent variables (Alhawaj et al., 2022; Arif, Sajjad, Farooq, Abrar, & Joyo, 2020; Bandeira Pinheiro, da Silva Filho, & Moreira, 2021; Rubino & Napoli, 2020; Skouloudis et al., 2019).

Only three researchers authored more than one article in the 55 articles reviewed. Dr. Greiling co-authored three articles (Slacik & Greiling, 2020b, 2020a; Traxler & Greiling, 2019) – two of which were co-authored by Dr. Slacik. These two articles focus on SR in electric utilities. Dr. Greiling's article co-authored with Dr. Traxler also focuses on electric utilities but from a sustainable public value reporting perspective. Dr. Boiral is the third researcher with multiple co-authored articles (Boiral & Heras-Saizarbitoria, 2020; Talbot & Boiral, 2018). Impression management in the energy sector was the focus of the 2018 paper (Talbot & Boiral, 2018). The purpose of the 2020 paper was to analyze the credibility of assurance statements for sustainability reports published by firms in these sectors (Boiral & Heras-Saizarbitoria, 2020).

5. CONCLUSIONS

Through analyzing the state of the art of research on SR in the energy sector this paper found that there are numerous research gaps. Based on this review it is recommended that research focuses on countries that will be transitioning to mandatory non-financial reporting imminently through the ISSB standards. Also, future research should look at the energy sector from a primary energy resource to end use consumption perspective in a more holistic approach that covers the multitude of subsectors that make up the energy sector. Future research should also bridge the gap between non-financial reporting research and accounting research. Finally, across the literature reviewed, "sustainability" is a commonly used and integral term, yet it is seriously abused from a sustainability science perspective. Further research should explore how sustainability science can be integrated into SR specifically in the energy sector.

REFERENCES

Alhawaj, A., Buallay, A., & Abdallhah, W. (2022). Sustainability reporting and energy sectorial performance - developed and emerging economies. *International Journal of Energy Sector Management*.

Arif, M., Sajjad, A., Farooq, S., Abrar, M., & Joyo, A. S. (2020). The impact of audit committee attributes on the quality and quantity of environmental, social and governance (ESG) disclosures. *Corporate Governance (Bingley)*, *21*(3), 497–514. https://doi.org/10.1108/CG-06-2020-0243

Bandeira Pinheiro, A., da Silva Filho, J. C. L., & Moreira, M. Z. (2021). Institutional drivers for corporate social responsibility in the utilities sector. *Revista de Gestao*, *28*(3), 186–204. https://doi.org/10.1108/REGE-08-2019-0088

Boiral, O., & Heras-Saizarbitoria, I. (2020). Sustainability reporting assurance: Creating stakeholder accountability through hyperreality? *Journal of Cleaner Production*, *243*. https://doi.org/10.1016/j.jclepro.2019.118596

Calabrese, A., Costa, R., Levialdi, N., Menichini, T., & Montalvan, R. A. V. (2020). Does more mean better? Exploring the relationship between report completeness and environmental sustainability. *Sustainability (Switzerland)*, *12*(24), 1–16. https://doi.org/10.3390/su122410635

Del Mar Alonso-Almeida, M., Llach, J., & Marimon, F. (2014). A closer look at the 'Global Reporting Initiative' sustainability reporting as a tool to implement environmental and social policies: A worldwide sector analysis. *Corporate Social Responsibility and Environmental Management*, *21*(6), 318–335. https://doi.org/10.1002/csr.1318

European Commission. (2023, January). Corporate sustainability reporting. Retrieved 30 April 2023, from https://finance.ec.europa.eu/capital-markets-union-and-financial-markets/company-reporting-and-auditing/company-reporting/corporate-sustainability-reporting_en

IFRS. (2021). *International <IR> Framework*. Retrieved from www.integratedreporting.org

IFRS. (2023, March). Seven key takeaways from the IFRS Sustainability Symposium. Retrieved 30 April 2023, from https://www.ifrs.org/news-and-events/news/2023/03/seven-key-takeaways-from-the-ifrs-sustainability-symposium/

Ilysheva, N., Karanina, E., Baldesku, E., & Zakirov, U. (2017). Detection of the interdependence of economic development and environmental performance at the industry level. *Montenegrin Journal of Economics*, *13*(4), 19–29. https://doi.org/10.14254/1800-5845/2017.13-4.2
Imperiale, F., Pizzi, S., & Lippolis, S. (2023). Sustainability reporting and ESG performance in the utilities sector. *Utilities Policy*, *80*. https://doi.org/10.1016/j.jup.2022.101468
Janik, A., Ryszko, A., & Szafraniec, M. (2020). Greenhouse gases and circular economy issues in sustainability reports from the energy sector in the European union. *Energies*, *13*(22). https://doi.org/10.3390/en13225993
Piesiewicz, M., Ciechan-Kujawa, M., & Kufel, P. (2021). Differences in disclosure of integrated reports at energy and non-energy companies. *Energies*, *14*(5). https://doi.org/10.3390/en14051253
Rubino, F., & Napoli, F. (2020). What impact does corporate governance have on corporate environmental performances? An empirical study of italian listed firms. *Sustainability (Switzerland)*, *12*(14), 1–21. https://doi.org/10.3390/su12145742
Skouloudis, A., Malesios, C., & Dimitrakopoulos, P. G. (2019). Corporate biodiversity accounting and reporting in mega-diverse countries: An examination of indicators disclosed in sustainability reports. *Ecological Indicators*, *98*, 888–901. https://doi.org/10.1016/j.ecolind.2018.11.060
Slacik, J., & Greiling, D. (2020a). Compliance with materiality in G4-sustainability reports by electric utilities. *International Journal of Energy Sector Management*, *14*(3), 583–608. https://doi.org/10.1108/IJESM-03-2019-0010
Slacik, J., & Greiling, D. (2020b). Coverage of G4-indicators in GRI-sustainability reports by electric utilities. *Journal of Public Budgeting, Accounting and Financial Management*, *32*(3), 359–378. https://doi.org/10.1108/JPBAFM-06-2019-0100
Talbot, D., & Boiral, O. (2018). GHG reporting and impression management: An assessment of sustainability reports from the energy sector. *Journal of Business Ethics*, *147*(2), 367–383. https://doi.org/10.1007/s10551-015-2979-4
Traxler, A. A., & Greiling, D. (2019). Sustainable public value reporting of electric utilities. *Baltic Journal of Management*, *14*(1), 103–121. https://doi.org/10.1108/BJM-10-2017-0337
Tsalis, T. A., Terzaki, M., Koulouriotis, D., Tsagarakis, K. P., & Nikolaou, I. E. (2022). The nexus of United Nations' 2030 Agenda and corporate sustainability reports. *Sustainable Development*. https://doi.org/10.1002/sd.2419

APPENDIX

Author(s)	Year Published	Title
Ahmed, R.I.; Zhao, G.; Ahmad, N.; Habiba, U.	2022	A nexus between corporate social responsibility disclosure and its determinants in energy enterprises
Alazzani, A.; Wan-Hussin, W.N.	2013	Global Reporting Initiative's environmental reporting: A study of oil and gas companies
Alhawaj, A.; Buallay, A.; Abdallah, W.	2022	Sustainability reporting and energy sectorial performance: developed and emerging economies
Alonso-Almeida, M.; Llach, J.; Marimon, F.	2014	A closer look at the 'Global Reporting Initiative' sustainability reporting as a tool to implement environmental and social policies: A worldwide sector analysis
Arif, M.; Sajjad, A.; Farooq, S.; Abrar, M.; Joyo, A.S.	2020	The impact of audit committee attributes on the quality and quantity of environmental, social and governance (ESG) disclosures
Ates, S.	2023	The credibility of corporate social responsibility reports: evidence from the energy sector in emerging markets
Badia, F.; Bracci, E.; Tallaki, M.	2020	Quality and diffusion of social and sustainability reporting in Italian public utility companies
Bartoszewicz, A.; Szczepankiewicz, E.I.	2022	Evolution of Energy Companies' Non-Financial Disclosures: A Model of Non-Financial Reports in the Energy Sector
Bashtovaya, V.	2014	CSR reporting in the United States and Russia
Beelitz, A.; Cho, C.H.; Michelon, G.; Patten, D.M.	2021	Measuring csr disclosure when assessing stock market effects
Behl, A.; Kumari, P.S.R.; Makhija, H.; Sharma, D.	2022	Exploring the relationship of ESG score and firm value using cross-lagged panel analyses: case of the Indian energy sector
Boiral, O.; Heras-Saizarbitoria, I.	2020	Sustainability reporting assurance: Creating stakeholder accountability through hyperreality?
Bondi, M.; Yu, D.	2019	Textual Voices in Corporate Reporting: A Cross-Cultural Analysis of Chinese, Italian, and American CSR Reports
Calabrese, A.; Costa, R.; Levialdi, N.; Menichini, T.; Montalvan, R.A.V.	2020	Does more mean better? Exploring the relationship between report completeness and environmental sustainability
Chelli, M.; Durocher, S.; Fortin, A.	2019	Substantive and symbolic strategies sustaining the environmentally friendly ideology: A media-sensitive analysis of the discourse of a leading French utility
Dawid, G.; Magdalena, K.; Karolina, K.	2019	CSR practices in Polish and Spanish stock listed companies: A comparative analysis
Delegkos, A.E.; Skordoulis, M.; Kalantonis, P.; Xanthopoulou, A.	2022	Integrated Reporting and Value Relevance in the Energy Sector: The Case of European Listed Firms
Dragomir, V.D.	2012	The disclosure of industrial greenhouse gas emissions: A critical assessment of corporate sustainability reports

Eng, L.L.; Fikru, M.G.	2022	Are US electric utilities improving their sustainability disclosures and performance?
Goloshchapova, I.; Poon, S.-H.; Pritchard, M.; Reed, P.	2019	Corporate social responsibility reports: topic analysis and big data approach
Hasan, I.; Singh, S.; Kashiramka, S.	2022	Does corporate social responsibility disclosure impact firm performance? An industry-wise analysis of Indian firms
Hossain, M.M.; Ahmmed, M.; Azam, M.K.G.; Islam, S.; Bhuiyan, M.F.; Hoque, M.A.	2020	Disclosure practices regarding corporate social responsibility (csr) of some listed companies: Evidence from chittagong stock exchange, bangladesh
Hourneaux Junior, F.; Galleli, B.; Gallardo-Vázquez, D.; Sánchez-Hernández, M.I.	2017	Strategic aspects in sustainability reporting in oil & gas industry: The comparative case-study of Brazilian Petrobras and Spanish Repsol
Ilysheva, N.; Karanina, E.; Baldesku, E.; Zakirov, U.	2017	Detection of the interdependence of economic development and environmental performance at the industry level
Imperiale, F.; Pizzi, S.; Lippolis, S.	2023	Sustainability reporting and ESG performance in the utilities sector
Janik, A.; Ryszko, A.; Szafraniec, M.	2020	Greenhouse gases and circular economy issues in sustainability reports from the energy sector in the European union
Karaman, A.S.; Orazalin, N.; Uyar, A.; Shahbaz, M.	2021	CSR achievement, reporting, and assurance in the energy sector: Does economic development matter?
Larsen, S.; Bentsen, N.S.; Stupak, I.	2019	Implementation of voluntary verification of sustainability for solid biomass - A case study from Denmark
Maji, S.G.; Kalita, N.	2022	Climate change financial disclosure and firm performance: empirical evidence from Indian energy sector based on TCFD recommendations
Mamun, M.	2022	Sustainability reporting of major electricity retailers in line with GRI: Australia evidence
Manes-Rossi, F.; Nicolo', G.	2022	Exploring sustainable development goals reporting practices: From symbolic to substantive approaches—Evidence from the energy sector
Mio, C.	2010	Corporate social reporting in Italian multi-utility companies: An empirical analysis
Miras-Rodríguez, M.M.; Di Pietra, R.	2018	Corporate Governance mechanisms as drivers that enhance the credibility and usefulness of CSR disclosure
Moseñe, J.A.; Burritt, R.L.; Sanagustín, M.V.; Moneva, J.M.; Tingey-Holyoak, J.	2013	Environmental reporting in the Spanish wind energy sector: An institutional view
Orazalin, N.; Mahmood, M.	2018	Economic, environmental, and social performance indicators of sustainability reporting: Evidence from the Russian oil and gas industry
Pasko, O.; Balla, I.; Levytska, I.; Semenyshena, N.	2021	Accountability on sustainability in Central and Eastern Europe: An empirical assessment of sustainability-related assurance
Pedrini, G.; Cappiello, G.	2022	The impact of training on labour productivity in the European utilities sector: An empirical analysis

Piesiewicz, M.; Ciechan-Kujawa, M.; Kufel, P.	2021	Differences in disclosure of integrated reports at energy and non-energy companies
Pinheiro, AB; da Silva, JCL; Moreira, MZ	2021	Institutional drivers for corporate social responsibility in the utilities sector
Raquiba, H.; Ishak, Z.	2020	Sustainability reporting practices in the energy sector of Bangladesh
Rubino, F.; Napoli, F.	2020	What impact does corporate governance have on corporate environmental performances? An empirical study of italian listed firms
Sensharma, S.; Sinha, M.; Sharma, D.	2022	Do Indian Firms Engage in Greenwashing? Evidence from Indian Firms
Sepúlveda-Alzate, Y.M.; García-Benau, M.A.; Gómez-Villegas, M.	2021	Materiality assessment: the case of Latin American listed companies
Sharma, D.; Bhattacharya, S.; Thukral, S.	2019	Resource-based view on corporate sustainable financial reporting and firm performance: Evidences from emerging Indian economy
Shvarts, E.; Bunina, J.; Knizhnikov, A.	2015	Voluntary environmental standards in Key Russian industries: A comparative analysis
Skouloudis, A.; Malesios, C.; Dimitrakopoulos, P.G.	2019	Corporate biodiversity accounting and reporting in mega-diverse countries: An examination of indicators disclosed in sustainability reports
Slacik, J.; Greiling, D.	2020	Coverage of G4-indicators in GRI-sustainability reports by electric utilities
Slacik, J.; Greiling, D.	2020	Compliance with materiality in G4-sustainability reports by electric utilities
Stocker, F; de Arruda, MP; de Mascena, KMC; Boaventura, JMG	2020	Stakeholder engagement in sustainability reporting: A classification model
Stuss, M.M.; Makieła, Z.J.; Herdan, A.; Kuźniarska, G.	2021	The corporate social responsibility of polish energy companies
Talbot, D.; Boiral, O.	2018	GHG reporting and impression management: An assessment of sustainability reports from the energy sector
Traxler, A.A.; Greiling, D.	2019	Sustainable public value reporting of electric utilities
Tsalis, T.A.; Terzaki, M.; Koulouriotis, D.; Tsagarakis, K.P.; Nikolaou, I.E.	2022	The nexus of United Nations' 2030 Agenda and corporate sustainability reports
Wang, J.; Sun, J.	2022	The role of audit committees in social responsibility and environmental disclosures: evidence from Chinese energy sector
Wasiuzzaman, S.; Ibrahim, S.A.; Kawi, F.	2022	Environmental, social and governance (ESG) disclosure and firm performance: does national culture matter?

ENERGY EFFICIENCY IMPROVEMENTS IN A PORTUGUESE CERAMIC INDUSTRY: CASE STUDY

Susana Carvalheira[1*], Miguel Oliveira[1,2], Margarita Robaina[1,2], João C. O. Matias[1,2]

[1] DEGEIT—Department of Economics, Management, Industrial Engineering, and Tourism, University of Aveiro, (Portugal);
[2]GOVCOPP—Research Unit on Governance, Competitiveness and Public Policies, University of Aveiro, (Portugal)
**Correspondence: susanacarvalheira@ua.pt*

Abstract

Considering the issues associated with climate change and reliance on external sources of energy, among others, the European Union and its commission have developed a strategy for transitioning to a climate-neutral economy by 2050. In this sense, a wide-ranging package was adopted to ensure the EU meets its climate and energy targets for the years 2020, 2030, and 2050. Hence, energy efficiency is a key principle of the European Union, as is energy saving and the development of new and renewable forms of energy. The most evident force is the European Efficiency Directive, adopted in 2012, which embraced a set of measures such as legal obligations to establish energy-saving schemes and/or alternative measures in the Member States. Concerning final energy consumption, the industrial sector is the second biggest consumer of final energy and one of the major contributors to greenhouse gas emissions. Some publications have studied the effectiveness of European policies, but they generally focus on a macro perspective. Few present case studies in specific industries, especially in intensive energy industries such as the ceramic industry. In this context, its higher consumption forces it to find solutions. From a challenge posed by the company, this paper presents a case study in the Portuguese ceramic industry, motivated by the high energy consumption and associated costs. The main purposes are to check the effectiveness of the applied measures resulting from the audit carried out in 2018, to improve energy efficiency, and to study the feasibility of implementing renewable energy sources. This case study provides a practical demonstration of how mandatory European policies and regulations at the member state level can help enterprises improve their energy efficiency. It also highlights the importance of evaluating renewable energy constraints rather than adopting them directly as a panacea.

Keywords: ceramic industry; IECMS; energy efficiency; renewable energy; retouching; case study

1 INTRODUCTION

Worldwide observed and anticipated climatic changes (CC) for the twenty-first century and global warming are significant global changes. Energy consumption has mounted greenhouse gas (GHG) levels concerning warming temperatures, as most of the energy production in developing countries comes from fossil fuels [1,2]. Examples of the impacts of climate change include the documentation of maximum and minimum temperatures observed in various regions of the world, the increase in average sea levels resulting in floods, the scarcity of potable water, and food insecurity [3]. Such impacts cannot be ignored, so it is imperative to resort not only to renewable energy sources but first of all to reduce energy waste. On the other hand, in the context of climate change, it is necessary to fulfill the commitments assumed at the Paris Agreement in 2015 and more recent ones, such as the Conference of the Parties (COP26) in Glasgow in 2021. This entails recognizing that energy is a vital factor in maintaining competitiveness between countries and their industries, but at the same time, it is the main source of greenhouse gas emissions. In this sense, the European Commission has a strategic long-term vision to lead the transition towards a climate-neutral economy by 2050, in line with the objectives of the Paris Agreement. The awareness of studying the impact of energy on different activities and economic sectors has gained renewed interest due to the growth and high variability of energy prices. This has been aggravated by recent world events, such as the COVID-19 Pandemic and the war in Ukraine. The need for decreasing energy imports (dependence) as a result of the standardization of energy prices will be mandatory due to the exponential pressure for the reduction in fossil energy consumption. Accordingly, the European Union considers as a priority the increase in energy efficiency and energy production through renewable sources (Portuguese Energy and Climate Plan (PECP—PNAC in Portuguese)) [4].

Concerning final energy consumption, the industrial sector is the second biggest consumer and a major contributor to GHG. Some publications have studied the effectiveness of European policies, but they generally focus on a macro perspective [5,6]. Few [7-9] present case studies in specific industries, particularly in intensive energy ones, such as the ceramic industry. In this context, its higher consumption forces it to find solutions. The industrial sector in Portugal consumes 30% of total national energy consumption [10,11] and is one of the sectors that most seek energy efficiency. The Portuguese Intensive Energy Consumption Management System (IECMS—SGCIE in Portuguese) is especially dedicated to industry, and it is under the operational management of ADENE (Portuguese Energy Agency). This program is operated at energy-intensive installations and realizes periodic energetic audits to analyze the use of energy in these facilities and to suggest measures to increase energy efficiency in the audited installations. In particular, the ceramic industry is highly energy-demanding, which makes this industry a key point for Portugal to achieve the objectives set out in the 2030 PNEC.
Having in mind the challenge posed by the company, the specific main aim of this study was to analyze the fulfillment of the settled goals in the Energy Consumption Rationalization Agreement (ARCE, in Portuguese) agreed upon between a Portuguese ceramic company and the ADENE. This study aimed to improve the company's energy efficiency, with a particular focus on increasing product quality, reducing retouching, and avoiding energy waste. Moreover, the feasibility of installing renewable energy production was studied, particularly solar and wind energy sources. This was conducted with the aim of considering renewable energy sources as the most affordable method to reduce energy costs and eliminate the use of fossil fuels, which have severe environmental impacts [9].

2 MATERIALS AND METHODS

The case study was the research method used, which is an empirical study that intends to determine or corroborate a theory. It suits operational and organizational dilemmas and allows the implementation of improvements to combat verified problems [12]. According to Yin [13], the case study belongs to the typology that qualitative research uses in a real context. The data collection takes place directly at the research site, and descriptive data collection techniques are used [13]. To this end, the research design adopted was focused on the PDCA cycle (Plan, Do, Check, and Act). In the initial phase of this study, it was necessary to gain an understanding of the factory's background and production process, from conformation to the selection section, through direct observation and interaction with employees from different sections of the factory. It was also necessary to understand how the equipments works, specifically the ones more energy intensive.
In the second phase, brainstorming sessions were conducted with employees at different hierarchical levels (from shop floor workers to the factory director) to explore solutions for improving equipment, methods, and processes. Then, the follow-up on the measures implemented and the suggestions of others was conducted. To carry out the energy characterization of the equipment, a thermal analysis was performed, in particular on the different furnaces, using a thermographic camera. The data provided by the company was also analyzed to determine its energy needs. In turn, using the RET-Screen® software, the feasibility of implementing renewable energy sources such as photovoltaic panels and wind turbines was studied. The implementation of energy management systems was also suggested.
At a later stage, the number of parts retouched was evaluated, and the energy gains represented by the reduction in the amounts of retouching were estimated, and the impact of this reduction on energy indicators was also analyzed. Some useful tools were used, standing out: (i) the Pareto chart [14]; the Ishikawa diagram [15] and the GUT matrix [16]. Finally, surveys were made to verify the gains that the proposed measures represent for the company, which allowed for drawing conclusions and identifying other possible improvements for future work.

3 RESULTS

3.1 Retouching Percentage

The retouching of pieces must be minimized, as it is impossible to eliminate it since it requires a new firing and requires time, which leads to a waste of resources (material, labor, energy, among other indirect ones). From the beginning of 2021 until the end of November, this unit had 14.21% of retouched parts, which is higher than the defined objective of 12%. Thus, it became important to analyze the most frequent defects during this period to understand their causes.

This type of cooking practiced in the company can generate more pores because sometimes the gas cannot escape between those layers. The company conducted various tests using pastes with different granulations to determine whether pore defects occurred less frequently based on the granulations of the pastes. This has not been the case, so tests continued to find a viable solution. The defect known as small faults of glass/single glass had 12,14%.

Still, another defect worth mentioning is the lack of glass/color, which was 8.26%. Such non-conformity occurs due to poor tuning of the glazing machines or anomalies of the machines themselves, which do not allow the piece to be glazed uniformly.

3.1.1 Prioritization of the Improvement Actions

The GUT matrix was used to prioritize different tasks based on well-defined criteria in a coherent ordering of actions. The importance and priority of the improvement actions were defined through the most alarming ones from the Ishikawa diagram. Five main problems stood out. Moreover, the final scores of the causes found based on their level of severity, urgency, and trend can be seen. Numbers from one to five were assigned, with five representing greater intensity and one representing less intensity.

According to the analysis, it was noticed that the causes of a higher GxUxT are caused by the labor force. The lack of quality control was found to be directly associated with the absence of control over various employees in different jobs. These employees were more attentive to their tasks when they felt that their work was being evaluated. The incorrect arrangement of the cars in the park, coupled with the lack of space, resulted in an appeal to the pride of the people responsible for transporting the cars between the different points of the production process. Thus, the high percentage of defects requiring retouching was mostly due to incorrect handling of parts. A prioritized action matrix was created and the actions are ordered based on the final scores obtained from the analysis of the problems.

3.2 Company's Objective and Main Actions

The company's objective is to reduce retouching to 12% by 2022. The causes/problems, and solutions found are described next:

3.2.1 Lack of quality control

It was necessary to conduct detailed and frequent quality inspections at different stages of the production process to detect defects early before firing. Such inspections are the most effective form of assessment. They are also crucial for planning which parts need to be fired in larger quantities to ensure orders are filled on time.

The results obtained throughout each week were treated and presented every Friday at the quality meetings. At the end of each month, a presentation was made with all the data for that month to verify performance and see where action could be taken to obtain better results, whenever possible. The meetings were also used to discuss the performance of different employees along the production line and assign responsibilties to those who caused the most frequent defects.

3.2.2 *Incorrect disposition of cars at the park*

It was proposed to demarcate it with bright yellow lines that would allow for better organization. The existing spaces are not enough to place more cars. The lack of space between cars leads to collisions between them and between parts, which leads to the creation of defects.

3.2.3 Non-compliance with the oven/defrost standards

The workers understood the importance of complying the standards, and images of the causes of the most alarming defects found were placed. In addition, the ovens on each shift were assessed for compliance with the standards. The implementation of such a mechanism allowed the suppliers to collaborate with the company to ensure compliance with the standards as much as possible. This action made it possible to reduce the defects caused by poor handling or other defects for which he was responsible, namely the nicated glaze.

3.2.4 Files outdated techniques

The glazing technical sheets were out of date, due to the existence of a large number of sheets recording the glazing conditions that were filled in manually by those responsible for these sections. The record sheets were filled out per shift and each sheet had more than one reference recorded. Digitizing this information was. To solve this problem and increase efficiency, software was developed to allow direct input of glazing conditions into the system.

3.2.5 Lack of air pressure in the cleaning machine

It was suggested the development of a more suitable one that would allow more effective cleaning of the plates. The new equipment has a greater range than the old one, greater airflow, and is capable of simultaneously scraping the kiln wagon plates.

3.3 Analysis of the Savings That the Reduction in Retouching Represents

The number of pieces retouched per year is 1,749,918 on average. A reduction of 1 percentage point in retouching corresponds to 1749.92 fewer parts to be retouched per year, that is, less than 1028.95 kg (the average weight of a part is 0.588 kg). In this sense, another 1749.92 good raw pieces can go into the kiln, which increases the company's gross added value (GVA). Such an increase will lead to a decrease in the energy intensity indicator, and the specific consumption indicator would also be influenced by such a decrease since consumption decreases. Pieces that require retouching typically have different temperature curves compared to raw pieces, as they do not need to be baked at such high temperatures. Intermittent ovens are widely used for decal firing, but also for touch-up firing. However, whenever possible, it is best to bake the re-touching pieces in the continuous oven. This oven consumes much less energy when compared to intermittent ones.

3.4 Impact on Energy Indicators

The best measure of energy efficiency is the reduction in retouching, as this allows the firing of pieces that are more likely to be sold at their maximum value with their highest quality (pieces classified as premium pieces). Quality control is essential for obtaining parts of assured quality, which positively impacts energy consumption. Specifically, there is a slight decrease in specific consumption and energy intensity indicators, while the carbon intensity indicator remains unchanged (Portuguese Law: Government Dispatch 17313/2008).

It is possible to infer that the more retouching there is, the greater the recorded consumption. This highlights the importance of reducing retouching and emphasizes the significance of quality control and the implemented actions to achieve the results outlined by the company. Despite several fluctuations throughout this study concerning the percentage of parts retouched, in April 2022 the company's objective was met since it presented 11.39% of parts classified as retouching. For this reason, the measures implemented and the quality inspections carried out ended up having a preponderant role in meeting the outlined objective of 12% retouching.

4 ANALYSIS OF THE IMPLEMENTATION OF ENERGY EFFICIENCY MEASURES FROM THE 2018 AUDIT

The company implemented some energy efficiency measures to comply with the Energy Rationalization Plan (in Portuguese PREn) of the audit carried out in 2018, namely: (i) replacing the Refractory Furniture in the Wagons with Low Thermal Mass Refractory Furniture from the Tunnel Kiln; (ii) replacement of the Thermal Insulation of the Continuous Furnace in the Firing Zone; (iii) recovery of the Final Cooling Air from the Tunnel Kiln to the Air Dryer and (iv) impact of Energy Efficiency Measures Implemented on the Specific Consumption Indicator.

After these measures, it is possible to verify an important impact on energy indicators, namely on the specific energy consumption indicator of the continuous oven. In the energy audit carried out in 2018, the continuous oven had an SEC of 306.7 kgoe/t. After the implementation of the aforementioned measures, it had an SEC of 229.8 kgoe/t (a reduction of 79.9 kgoe/t). Thus, the reduction in a load of refractory material, the reduction in losses due to heat leakage in the furnace, and the practically total use of the heat coming from cooling for the air dryer and preheating through ducts allowed for significantly reduced specific energy consumption and consequently lower energy costs. Such energy efficiency measures had a preponderant impact on the company to achieve the objectives defined in the PNEC30.

5 SUGGESTED MEASURES TO REDUCE ENERGY CONSUMPTION AND/OR ENERGY COSTS

5.1 Power Generation System through Photovoltaic Panels

The company presents a small photovoltaic power station in its own facilities, with 408 panels. The installed power is around 108 kW. The dimensioning of this plant was designed so that during the period of less work (at the weekend), all the energy produced would be consumed within the company itself, and there would be no need to inject energy into the network. There is a lot of unused space at the moment, a space where more photovoltaic panels can be placed. In addition to the photovoltaic system, the company also has solar panels to produce domestic hot water (DHW).

Due to the global requirements regarding the adoption of renewable energies, it is important to study the feasibility of their implementation. To obtain an estimate of the amount of energy produced by this technology, the RETScreen® software was used to model it. A load diagram was collected, and it allows us to conclude that the factory only has appreciable consumption between 9 a.m. and 8 p.m., with a reasonably constant load profile on working days and clearly lower on weekends, when the load drops to around 100 kWh. This finding proves the goodness of the selection of the currently installed power.

However, it is assumed that the almost constant consumption during working hours on weekdays (almost rectangular profile) admits an increase in installed power to values close to 400 kW, i.e., an increase close to 300 kW. It should be noted that a solar unit always needs a correct articulation between the number of solar modules and the characteristics of the inverter to be used, leading to a discrete number. Usually, the peak power of the modules is higher than the power of the inverter; otherwise, the inverter would be wasted. In this way, three different scenarios were considered, taking this into account.

In the first phase, a model of photovoltaic inverters was selected. The considered three-phase inverter presents a maximum efficiency of 98.1%, with a maxi-mum input power of 75 kW and a nominal output power of 50 kW. It has a maximum input voltage of 1000 Vdc (voltage direct current) with a range of 500 to 800 Vdc and a capacity of 27 kW. In addition, the necessary accessories for correct installation are included. The unit price is €4630.28. The costs for its installation are €21.8 per unit. The decennial maintenance costs (in the first 10 years) are €718.85.

Regarding the photovoltaic solar modules used, each monocrystalline silicon cell module has a maximum power of 590 W and an efficiency of 21.03%. Its voltage at maximum power is 44.77 V and its maximum current is 13.17 A. The unit cost is €228.92. The costs for its installation are €21.05 per unit. The decennial maintenance costs (in the first 10 years) are €37.50.

To carry out the sizing of each of the components mentioned above, it was necessary to understand the factory's energy needs. The contracted power is 579.61 kW. This power already considers the installed self-consumption production system, since this was implemented in 2017. Therefore, this value was the base value for carrying out the different scenarios, but always bearing in mind the factors considered (around 70%, around 55%, and around 40%), we estimated the best scenario to implement, taking in-to account the internal rate of return (IRR).

In the energy model of each of the conducted scenarios, the considered solar positioning system of the panels was the fixed one, and the panels' inclination was 11° (according to the company's architect) in two different orientations depending on the inclination of the roof. In this study, measurements for an inclined surface were considered. The different scenarios almost guarantee the consumption of electricity on working days, but will bring excess energy on weekends that will have to be injected into the network at market price. The average electricity price from the network was

calculated using consumption for the year 2022, for solar time, that is, peak and flood periods. The prices for each tariff period were obtained through the analysis of a February electricity bill provided by the company. The average electricity cost considered for the financial analysis was €64.02/MWh.

Of the contracted power of 579.61 kW and considering the inverter's rated power of 50 kW, the three scenarios of 70%, 55%, and 40% of consumption correspond, respectively, to a power to be installed of 405.73 kW, 579.61 kW, and 231.84 kW. This means the need to install 8.11, 6.38, or 4.64 inverters, respectively, in each case.

As inverters cannot be installed, it was considered: (i) 400 kW of minimum power to be installed and 9 inverters, which corresponds to 69.01% of consumption, in the 70% scenario, with 678 photovoltaic modules needed; (ii) 350 kW, which corresponds to 60.39% of consumption, in the 55% scenario, with 594 photovoltaic modules; and (iii) 231.84 kW, which corresponds to 43.13% of consumption, in the 40% scenario, with 424 photovoltaic modules needed.

The total investment costs are €211,348, €181,047, and €129,248; labor costs for the first installation are €14,468, €12,656, and € 9034, respectively, for each scenario. Regarding the environmental analysis, there would be an annual reduction in GHG emissions of 153.5 tCO2, 134.3 tCO2, and 95.9 tCO2. The revenue from clean energy production is 597 MWh/year, 523 MWh/year, and 373 MWh/year and the energy generation cost are 14.15 €/MWh, 13.86 €/MWh, and 13.85 €/MWh. The IRR is 17.8%, 18.2%, and 18.2%. The payback of this project for the three scenarios would be 5.5, 5.4, and 5.4 years, which means that the project is financially viable.

IRR intends to measure the profitability of investment projects. The higher this indicator is, the more profitable the project under study. Comparing the different scenarios and their respective indicators—IRR and payback—there is a great proximity of values, with scenarios of around 55% and 40% being the best ones.

5.2 Energy Generation System Based on Wind Turbines

The cost of the wind turbine was consulted on the Hummer platform (Hummer H25.0–200 kW—Livre Power, Lda, http://livre.pt/pt/185-hummer, undated). The average price of electricity from the grid was calculated using consumption for the year 2022. The prices for each tariff period were obtained by analyzing a February electricity bill provided by the company. The average electricity cost considered for the financial analysis was €60.78/MWh.

The factory has a contracted power of 579.61 kW. In line with the best scenario found for the photovoltaic system, the installation of a wind turbine began by dimensioning to satisfy a power of 450 kW. The considered wind turbine has a nominal power of 210 kW. Thus, it is necessary to install two wind turbines. We concluded that the project is not viable. The return on equity is greater than the lifetime of the project, and no energy production is expected. The area where the factory is located is characteristically an area of constant winds with an annual average speed of 2.3 m/s. This make this wind turbine project unfeasible because the turbine needs winds of around 3 m/s to produce energy.

The company did not have an energy consumption monitoring system. This fact made it impossible to break down the consumption of all the machines. The simultaneity of its operation also made this disaggregation difficult. According to ISO 50001:2018, the implementation of an energy management system (EnMS) allows for the creation of conditions that improve energy efficiency, but it does not, by itself, guarantee energy efficiency. The implementation of a monitoring system does not directly result in a reduction in energy consumption. However, if well-designed, it can facilitate the identification of less efficient sources and enable the correction of these inefficiencies, leading to energy savings. Organizations can seek certification if they implement an EnMS in accordance with the ISO 50001:2018 standard and find it suitable for their needs. However, regardless of certification, the advantages of implementing this type of system are as follows [17]: (i) preservation of natural resources; (ii) decrease in environmental pollution (iii) reduction in energy costs; (iv) greater energy efficiency; (v) compliance with legal requirements; (vi) standing out in relation to the competition that still does not consider this cause and (vii) improvement of the organization’s image reveals a concern with environmental issues.

In general, and according to Gaspar [18], typical savings acquired exclusively from monitoring and controlling energy consumption can be 3% in the case of electrical consumption and 5% for other forms of energy. Now, to assess the hypothetical annual savings that the adoption of an EnMS would bring to the company, energy consumption for the year 2021 was considered, with potential savings of 3% for electricity consumption and 5% for natural gas. Thus, in 2021, the factory consumed 380 toe of electricity and 938 toe of natural gas. Such consumption would represent a total savings of €16,173 (€5522 in electricity and €10,651 in natural gas). With an initial investment of around €20,510, according to the study carried out by Bezerra [19], the estimated return can be obtained in 1.27 years. This value is within acceptable values according to the Intensive Energy Consumption Management System [20]. The IECMS states that the implementation of this measure has an average payback of 3 years, and the financial return value can vary between 1.2 years and 3.2 years.

Still, in the context of an energy management system, increasing efficiency in energy consumption depends a lot on the individual responsibility of each employee at their workstations. That is why it is extremely important to raise the awareness of all employees about the adoption of good energy efficiency practices in the daily operation of the company. The adoption of such behaviors can result in a reduction in consumption and a consequent reduction in the energy bill, eliminating unnecessary expenses.

Training in energy efficiency makes it possible to indirectly reduce energy consumption through the adoption of more efficient and sustainable practices in the company. There is still little environmental awareness among people, so alerting them to this issue is crucial. Some of the most common habits observed in the company that represent unnecessary expenses are cleaning clothes and surfaces with compressed air, leaving lights on unnecessarily, keeping air conditioning on in the winter, and not turning off computers overnight.

6 CONCLUSIONS

Two different factors were perceived to improve energy consumption throughout the production process: the percentage of retouching and the quality required for the final product. These two factors are crucial for the company’s energy consumption and the costs it entails. Reducing the number of retouched parts required, aligning employees with the company’s objectives, insisting on the correct handling of parts, and also insisting on the importance of complying with work standards.

Monitoring some of the energy efficiency measures applied by the company as a result of the last energy audit was an important step towards realizing that the measures were successfully applied. These measures had a real impact on the company’s energy savings. The exchange of refractory furniture for refractory furniture with low thermal mass, the replacement of the thermal insulation of the continuous furnace, and the use of the final cooling air from the continuous furnace for the aerial dryer resulted in a decrease in the specific consumption of the continuous oven. This reduction in energy consumption represents cost savings for the company. The company’s potential for the installation of renewable energies was also perceived, namely the installation of photovoltaic panels and the advantages that this would bring to the company in the long term. In addition to being able to self-produce its own energy and reduce energy costs, the company has contributed to a greener world. All of this is in line with the company’s environmental concerns. It is important to highlight the importance of raising the awareness of different employees about the energy crisis that we are experiencing. It is crucial to keep people motivated and aware to walk in the same direction and think about the benefits for the company and consequently for each one individually.

Some limitations were felt with this study, as the lack of training for employees in the different sections where quality inspections were carried out led to some resistance to the suggestions made. In addition, the Retscreen® software does not allow a distinction between weekday and week-end energy consumption, which influenced the data obtained in the different studied scenarios.

As a final remark, it is important to note that this case study provides a good practical example of how policies and regulations can contribute to fostering enterprise energy efficiency and the use of renewable energy as a potential solution. Therefore, it can inspire other intensive energy industries, mainly ceramic facilities, to adopt similar sustainable measures.

REFERENCES

[1] Balsalobre-Lorente,D.; Ibáñez-Luzón,L.; Usman,M.; Shahbaz,M. The environmental Kuznets curve, based on the economic complexity, and the pollution haven hypothesis in PIIGS countries. *Renew. Energy* **2022,** *185*, 1441–1455.

[2] Usman,M.; Jahanger,A.; Makhdum,M.S.A.; Balsalobre-Lorente,D.; Bashir,A. How do financial development, energy consumption, natural resources, and globalization affect Arctic countries' economic growth and environmental quality? An advanced panel data simulation. *Energy* **2022,** *241*, 122515.https://doi.org/10.1016/j.energy.2021.122515.
[3] Cha,H.; Moon,J.H.; Kim,T.; Song,Y.T. Underlying drivers of decade-long fluctuation in the global mean sea-level rise.*Environ. Res. Lett.* **2021**,*16*, 124064.https://doi.org/10.1088/1748-9326/ac3d58.
[4] Plano Nacional Energia e Clima (PNEC2030). *National Energy and Climate Plan 2021-2030 (PNEC2030) [In Portuguese: Plano Nacional Energia EClima 2021-2030 (PNEC2030)*];BCSD Portugal: Lisboa, Portugal,2019.Available online: https://bcsdportugal.org/wp-content/uploads/2020/12/PNEC-2030-Plano-Nacional-Energia-e-Clima.pdf .(accessed on 27 April 2022).
[5] Malinauskaite,J.; Jouhara,H.; Egilegor,B.; Al-Mansour,F.; Ahmad,L.; Pusnik,M. Energy efficiency in the industrial sector in the EU, Slovenia, and Spain. *Energy* **2020**, *208*, 118398. https://doi.org/10.1016/j.energy.2020.118398.
[6] Bertoldi, P.; Mosconi, R. Do energy efficiency policies save energy? A new approach based on energy policy indicators in the EU Member States. *Energy Policy* **2020**, *139*, 111320. https://doi.org/10.1016/j.enpol.2020.111320.
[7] Kong, L.; Zhao, J.; Li, J.; Lou, R.; Zhang, Y. Evaluating energy efficiency improvement of pulp and paper production: Case study from factory level. *J. Clean. Prod.* **2020**, *277*, 124018. https://doi.org/10.1016/j.jclepro.2020.124018. ISSN0959-6526.
[8] Hu, L.; Tang, R.; Cai, W.; Feng; Y; Ma, X. Optimisation of cutting parameters for improving energy efficiency in machining process. *Robot. Comput.-Integr. Manuf.* **2019,** *59*, 406–416. https://doi.org/10.1016/j.rcim.2019.04.015.ISSN0736-5845.
[9] Olabi, A.G. Mohammad Ali Abdelkareem, Renewable energy and climate change. *Renew. Sustain. Energy Rev.* **2022**, *158*, 112111. https://doi.org/10.1016/j.rser.2022.112111. ISSN1364-0321.
[10] Direção Geral de Energia e Geologia. *National Energy Balance 2020* [*in Portuguese: Balanço Energético Nacional 2020*]; Direção Geral de Energia e Geologia: Lisboa, Portugal, **2021**. https://doi.org/10.4000/configuracoes.7853.
[11] Direção Geral de Energia e Geologia. *Agência Para a Energia. Energy in Numbers* [*in Portuguese: Energia em Números*]; Direção Geral de Energia e Geologia: Lisboa, Portugal, 2021. Available online: https://www.dgeg.gov.pt/media/32skj5iv/dgeg-aen-2021e.pdf (accessed on 27 April 2022).
[12] Brown, L. A., George, B., & Mehaffey-Kultgen, C. (2018). The development of a competency model and its implementation in a power utility cooperative: an action research study. *Industrial and Commercial Training*, *50*(3), 123–135. https://doi.org/10.1108/ICT-11-2017-0087
[13] Yin,R.K. *Case Study Research. Design and Methods*, 3rded.; SAGE Publications: Newbury Park, CA, USA, 2018.
[14] Tian,J.J.; Sun,N.; Fei,F.; Zeng,H.J.; Yang,Z.F.; Fan,X.J.; Zhao,S.S. Defects and failure modes of automobile braking system based on pareto diagram. In Proceedings of 4th International Conference on Electromechanical Control Technology and Transportation (ICECTT), Guilin, China, 26–28 April 2019; pp. 57–61. https://doi.org/10.1109/ICECTT.2019.00020.
[15] Rosário,C.R.; Kipper,L.M.; Frozza,R.; Mariani,B.B. Modelling of tacit knowledge in industry: Simulations on the variables of industrial processes. *Expert. Syst. Appl.* **2015**, *42*, 1613–1625. https://doi.org/10.1016/j.eswa.2014.09.023.
[16] Hékis,H.R.; Silva,Á.C.; Oliveira,I.M.P.; Araujo,J.P. GUT analysis and information management for decision making in an organic products company in Rio Grande do Norte [in Portuguese: Análise GUT e a Gestão da Informação para tomada de decisão em uma empresa de produtos orgânicos do Rio Grande do Norte]. *Rev. Tecnol.* **2013**, *34*, 20–32. Available online: https://periodicos.unifor.br/tec/article/view/4485, (accessed on 19 November 2021).
[17] Bovkun,A.S.; Yanyushkin Sergey,A.; Sobolev,A.S.; Schupletsov,A.F.; Beregova,G.M. Implementation of ISO50001 standard in the activities of energy companies. In Proceedings of the-ICOECS2021: 2021 International Conference on Electrotechnical Complexes and Systems 2021, Ufa, Russia, 16–19 November 2021; pp. 417–420. https://doi.org/10.1109/ICOECS52783.2021.9657231.
[18] Gaspar,C. *Energy Efficiency in Industry.* [*in Portuguese Eficiência Energética na Indústria*]; Agência Portuguesa da Energia: Gaia, Portugal, 2004; pp.1–89.
[19] Bezerra, A. Critical Analysis of Energy Consumption in the Faience Industry [in Portuguese: Análise Crítica do Consumo de Energia na Indústria da Faiança]. Master's Thesis, Repository of the University of Aveiro, Aveiro, Portugal, 2015. Available online: https://ria.ua.pt/bitstream/10773/16045/1/tese.pdf.(accessed on 10 January 2022)
[20] Sistemas de Gestão dos Consumos Intensivos de Energia. *Manufacture of Household Articles of Earthenware, Porcelain and Fine Stoneware [in portuguese: Fabricação de Artigos de Uso Doméstico de Faiança, Porcelana e Grés Fino*]; Agência Nacional de Energia: Lisboa, Portugal, 2019. Available online:

https://sgcie.pt/wp-content/uploads/2019/10/23412-PORCELANA-E-GR%C3%89S-FINO-Caderno.pdf (accessed on 10 December2022).

CHARACTERIZATION OF THE ECONOMIC, ENVIRONMENTAL, AND SOCIAL IMPACTS OF RENEWABLE ENERGIES

Edimar Ramalho[2]; Max López-Maciel[3]; Mara Madaleno[1,2]; José Villar[4]; Marta Dias[1,2]; Anabela Botelho[1,2]; Margarita Robaina[1,2]

[1]Research Unit on Governance, Competitiveness and Public Policies (GOVCOPP)
[2]DEGEIT, University of Aveiro, Campus Universitário de Santiago,
[3] CESAM & Department of Environment & Planning, Aveiro University (DAO-UA), Portugal
[4] Centre for Power and Energy Systems, INESC TEC, Campus da FEUP, Rua Dr Roberto Frias, 4200-465 Porto, Portugal

Keywords: Economic Impact, Environmental Impact, Renewable Energy, Social Impact, Sustainability, metrics, indicators.

Long Abstract

Renewable energy is the path to energy transition and an alternative to make the world more sustainable. However, sustainability depends on the balance of three pillars: economic, environmental and social. These pillars can be conflicting, making sustainability complex. Thus, with the objective of making the analysis of the impact of renewable energy more objective and systematic, this article proposes to point out the main metrics that characterize the impacts: economic, environmental, and social. Seven metrics were described for the environmental impact, four for the economic impact and five for the social impact. Only metrics that presented a clear and concise definition were selected. The key finding was that literature does not agree on how to categorize what constitutes economic, environmental, and social impact. Measuring each influence's impact may be challenging for several reasons, including the used approach (micro or macro). The emphasis of this work is on these two approaches: Macro-Studies and Micro-Studies. First, focusing on global and aggregate impact and second, focusing on regional and local impacts.

Scientific articles on the economic, social, and environmental impacts of renewable energies covering the research criteria were transmitted over time with an upward trend from 2012 to now. Our sample of 38 articles distributed over time shows the growing interest of researchers in the topic. On annual average, at least three articles are published from 2012 to 2022. The growing increase in the theme was already expected, as there is an expectation of transition from fossil energies to renewable energies following the Paris agreement and national agendas. Only metrics that presented a clear and concise definition were selected.

Environmental Impact

The environmental impact was discussed in 21 articles of the 38 analysed. There is a balance between the micro and macro approach, 11 studies adopted a macro approach and 10 adopted the micro approach. The metrics that were constantly cited in the literature were Greenhouse Gas (GHG) Emissions, Air pollution, Land use, Bird mortality, Biodiversity, Wildlife and Water. The most cited metric was GHG emissions. Generally, this metric is measured as CO2 emissions savings [1]. However, there are works that include other pollutants, such as nitric oxides (NOx), or sulfur dioxide (SO2) [2]. GHG emissions are evaluated by what is avoided in the substitution of conventional energy sources for renewable energy [3], [4]. The second most cited, Air pollution, is estimated by air quality after implementation of renewable energy [5], [6], [7], [8]. Land use can be described by the reduction in the quality and quantity of the resources that the land can give [9] or income generated by having leased or sold the land for the construction of the plant [8].

Conceptually, Bird mortality, Biodiversity and Wildlife are similar metrics, the metric of bird mortality and more specific, referring only to the number of birds that were killed with the implementation of the power plant. Biodiversity and wildlife involve the animals' quality of life [9] and how much the power plant harmed nature [10]. Regarding to water metric, it refers to the amount of water saved or used in the exchange of conventional energy for renewable energy.

Economic Impact

The economic impact was discussed in 21 articles of the 38 analysed. Many of the studies that analyzed the environmental impact also analyzed the economic impact, there are 14 papers in the total of 21. The other studies were merely economic analysis [11], [12], [13]– [15] or merely financial [16].

The main metrics were Gross Domestic Product (GDP), Energy Cost, Money, and Employment. There were 11 macro studies and 10 micro studies. GDP as the most commented metric in the literature, 2 papers in micro studies and 7 in macro studies. This metric measures economic growth in dollars with the use of renewable sources [17]. The energy metric can be measured from production costs plus profits and taxes [18] or by people's perceptions of the cost of energy in replacing fossil energy with renewable energy [19]. Money metric means the power plant implementation has brought more investments and higher wages into the region [20], [5]. Employment was identified twice in macro studies and defined by the number of jobs created in the community as a whole [21], [22].

Social Impact

The largest number of works found in the literature was on social impact, with 27 of the 38 analyzed. There are 14 works that emphasized micro studies and 13 that focused on macro studies.

The main metric found was Job Creation. This metric is commonly found in literature to explain the social impact. One way that social impact contributes to both public acceptance and local development is by, for example, influencing the local economy because of this new industrial activity [23]. In a study conducted in Ouarzazate, Morocco, the issue of community acceptance of a flagship concentrated solar energy project in the MENA region (Middle East and North Africa) was investigated with the aim of exploring factors such as procedural and distributive justice and trust. They carried out 232 interviews and found that the community did not have much knowledge about the project and that acceptance of the project is practically universal because solar energy is considered beneficial for the environment [24]. It is concluded that there is an influence of the project on the local economy, however, this project was not accompanied by the knowledge of the people.

Employment metric, which was also used as a social impact, and is associated with the amount of work that the power plant can offer [18], [6]. In addition, the employment can be divided into short term (connected with RES construction) and long term (connected with operation). Livelihoods metric means for instance, the fear that water availability may be directly impacted by water withdrawals for reservoirs, decreasing the ability to continue agricultural operations [25] or when people lose their settlement due to the construction of dams [10]. Regarding Decent work metric, it consists in all the human rights of workers in the phases of construction, transport and maintenance of the power plant [26], [27]. And lastly, the Cultural and natural heritage, this metric is a feeling of injustice to their cultural heritage, that may have negative effects on the cultural traditions, values and styles of the region [25], [26], [28].

Conclusions

This work proposed to survey the metrics of renewable energies impacts, focusing on the three pillars of sustainability: economic impact, environmental impact and social impact. For a more objective and systematic analysis, the standardization of these metrics is extremely important. For this, this study raised the main metrics of each sustainability pillar and separated by macro and micro approach. The main result found was that there is no agreement in the literature in the classification of what is economic impact, environmental impact and social impact when analyzed as a whole of the three impacts. In addition, some articles use the term socio-economic impact, referring to economic and social impact together. Depending on how the study was approached, a particular metric can be characterized as one or another impact, for example, employment metric. One of the reasons that make metrics for each impact difficult may be how to study the impact: micro or macro. Global impacts are effects that exceed the local community, so the same metric can generate two effects depending on the spectrum analysed. It is concluded that the social impact is the most difficult effect to measure, as it depends on several factors, such as the type of plant, location, profile of people in the community, and other factors. Social impact, along with environmental impact, are the effects that should be most carefully measured. This study demonstrates with a set of metrics that the use of renewable energy has different effects on sustainability, whether in economic, environmental, or social aspects, addressed separately at the micro and macro level. Future research can be carried out to apply this framework and verify if there are significant differences in relation to the micro and macro approach.

REFERENCES

[1] V. Sebestyén, “Renewable and Sustainable Energy Reviews: Environmental impact networks of renewable energy power plants,” *Renewable and Sustainable Energy Reviews*, vol. 151, p. 111626, Nov. 2021, doi: 10.1016/J.RSER.2021.111626.

[2] S. A. Sarker *et al.*, “Economic Viability and Socio-Environmental Impacts of Solar Home Systems for Off-Grid Rural Electrification in Bangladesh,” *Energies (Basel)*, vol. 13, no. 3, p. 679, Feb. 2020, doi: 10.3390/en13030679.

[3] F. F. Freitas *et al.*, “Study of the Potential for Energy Use of Biogas From a Wastewater Treatment Plant To a Medium-Sized City: A Technical, Economic and Environmental Analysis,” *Waste Biomass Valorization*, vol. 13, no. 8, pp. 3509–3521, Aug. 2022, doi: 10.1007/s12649-022-01727-8.

[4] K. Almutairi, G. Thoma, and A. Durand-Morat, “Ex-Ante Analysis of Economic, Social and Environmental Impacts of Large-Scale Renewable and Nuclear Energy Targets for Global Electricity Generation by 2030,” *Sustainability*, vol. 10, no. 8, p. 2884, Aug. 2018, doi: 10.3390/su10082884.

[5] S. A. Sarker *et al.*, “Economic Viability and Socio-Environmental Impacts of Solar Home Systems for Off-Grid Rural Electrification in Bangladesh,” *Energies (Basel)*, vol. 13, no. 3, p. 679, Feb. 2020, doi: 10.3390/en13030679.

[6] H. Zhao and S. Guo, “External Benefit Evaluation of Renewable Energy Power in China for Sustainability,” *Sustainability*, vol. 7, no. 5, pp. 4783–4805, Apr. 2015, doi: 10.3390/su7054783.

[7] L. Blickwedel, L. Stößel, R. Schelenz, and G. Jacobs, “Multicriterial Evaluation of Renewable Energy Expansion Projects at Municipal Level for the Available Biomass Potential,” *Energies (Basel)*, vol. 13, no. 23, p. 6211, Nov. 2020, doi: 10.3390/en13236211.

[8] J. Macháč and L. Zaňková, “Renewables—To Build or Not? Czech Approach to Impact Assessment of Renewable Energy Sources with an Emphasis on Municipality Perspective,” *Land (Basel)*, vol. 9, no. 12, p. 497, Dec. 2020, doi: 10.3390/land9120497.

[9] A. Gawande and P. Chaudhry, “Environmental and social impacts of wind energy: a view point with reference to India,” *Ecological Questions*, vol. 30, no. 2, p. 39, Mar. 2019, doi: 10.12775/EQ.2019.009.

[10] R. Peters, J. Berlekamp, A. Lucía, V. Stefani, K. Tockner, and C. Zarfl, “Integrated Impact Assessment for Sustainable Hydropower Planning in the Vjosa Catchment (Greece, Albania),” *Sustainability*, vol. 13, no. 3, p. 1514, Feb. 2021, doi: 10.3390/su13031514.

[11] K. Nhiakao, H. Yabar, and T. Mizunoya, “Cost-Benefit Analysis of the Nam Che 1 Hydropower Plant, Thathom District, Laos: An Ex-Post Analysis,” *Sustainability*, vol. 14, no. 6, p. 3178, Mar. 2022, doi: 10.3390/su14063178.

[12] L. T. Clausen and D. Rudolph, “Renewable energy for sustainable rural development: Synergies and mismatches,” *Energy Policy*, vol. 138, p. 111289, Mar. 2020, doi: 10.1016/J.ENPOL.2020.111289.

[13] M. Bukowski, J. Majewski, and A. Sobolewska, “Macroeconomic Electric Energy Production Efficiency of Photovoltaic Panels in Single-Family Homes in Poland,” *Energies (Basel)*, vol. 14, no. 1, p. 126, Dec. 2020, doi: 10.3390/en14010126.

[14] S. Kahouli and J. C. Martin, “Can Offshore Wind Energy Be a Lever for Job Creation in France? Some Insights from a Local Case Study,” *Environmental Modeling & Assessment*, vol. 23, no. 3, pp. 203–227, Jun. 2018, doi: 10.1007/s10666-017-9580-4.

[15] N. Magnani and A. Vaona, “Regional spillover effects of renewable energy generation in Italy,” *Energy Policy*, vol. 56, pp. 663–671, May 2013, doi: 10.1016/j.enpol.2013.01.032.

[16] D. Myšáková, I. Jáč, and M. Petrů, “Investment opportunities for family businesses in the field of use of biogas plants,” *E+M Ekonomie a Management*, vol. 19, no. 4, pp. 19–32, Dec. 2016, doi: 10.15240/tul/001/2016-4-002.

[17] P. Behrens, J. F. D. Rodrigues, T. Brás, and C. Silva, “Environmental, economic, and social

impacts of feed-in tariffs: A Portuguese perspective 2000–2010,” *Appl Energy*, vol. 173, pp. 309–319, Jul. 2016, doi: 10.1016/J.APENERGY.2016.04.044.
[18] A. Barragán-Escandón, E. Zalamea-León, and J. Terrados-Cepeda, “Incidence of Photovoltaics in Cities Based on Indicators of Occupancy and Urban Sustainability,” *Energies (Basel)*, vol. 12, no. 5, p. 810, Feb. 2019, doi: 10.3390/en12050810.
[19] P. Gargallo, N. García-Casarejos, and M. Salvador, “Perceptions of local population on the impacts of substitution of fossil energies by renewables: A case study applied to a Spanish rural area,” *Energy Reports*, vol. 6, pp. 436–441, Feb. 2020, doi: 10.1016/j.egyr.2019.08.085.
[20] E. Martínez-Mendoza, L. A. Rivas-Tovar, E. Fernández-Echeverría, and G. Fernández-Lambert, “Social impact of wind energy in the Isthmus of Tehuantepec, Mexico, using Likert-fuzzy,” *Energy Strategy Reviews*, vol. 32, p. 100567, Nov. 2020, doi: 10.1016/j.esr.2020.100567.
[21] D. Hartono, S. H. Hastuti, A. Halimatussadiah, A. Saraswati, A. F. Mita, and V. Indriani, “Comparing the impacts of fossil and renewable energy investments in Indonesia: A simple general equilibrium analysis,” *Heliyon*, vol. 6, no. 6, p. e04120, Jun. 2020, doi: 10.1016/j.heliyon.2020.e04120.
[22] J. Mamkhezri, L. A. Malczynski, and J. M. Chermak, “Assessing the Economic and Environmental Impacts of Alternative Renewable Portfolio Standards: Winners and Losers,” *Energies (Basel)*, vol. 14, no. 11, p. 3319, Jun. 2021, doi: 10.3390/en14113319.
[23] P. Chazara, S. Negny, and L. Montastruc, “Quantitative method to assess the number of jobs created by production systems: Application to multi-criteria decision analysis for sustainable biomass supply chain,” *Sustain Prod Consum*, vol. 12, pp. 134–154, Oct. 2017, doi: 10.1016/j.spc.2017.07.002.
[24] S. Hanger, N. Komendantova, B. Schinke, D. Zejli, A. Ihlal, and A. Patt, “Community acceptance of large-scale solar energy installations in developing countries: Evidence from Morocco,” *Energy Res Soc Sci*, vol. 14, pp. 80–89, Apr. 2016, doi: 10.1016/j.erss.2016.01.010.
[25] J. Terrapon-Pfaff, T. Fink, P. Viebahn, and E. M. Jamea, “Social impacts of large-scale solar thermal power plants: Assessment results for the NOORO I power plant in Morocco,” *Renewable and Sustainable Energy Reviews*, vol. 113, p. 109259, Oct. 2019, doi: 10.1016/j.rser.2019.109259.
[26] B. Corona, K. P. Bozhilova-Kisheva, S. I. Olsen, and G. San Miguel, “Social Life Cycle Assessment of a Concentrated Solar Power Plant in Spain: A Methodological Proposal,” *J Ind Ecol*, vol. 21, no. 6, pp. 1566–1577, Dec. 2017, doi: 10.1111/jiec.12541.
[27] T. S. Aung, T. B. Fischer, and A. S. Azmi, “Social impacts of large-scale hydropower project in Myanmar: a social life cycle assessment of Shweli hydropower dam 1,” *Int J Life Cycle Assess*, vol. 26, no. 2, pp. 417–433, Feb. 2021, doi: 10.1007/s11367-021-01868-3.
[28] M. Langbroek and F. Vanclay, “Learning from the social impacts associated with initiating a windfarm near the former island of Urk, The Netherlands,” *Impact Assessment and Project Appraisal*, vol. 30, no. 3, pp. 167–178, Sep. 2012, doi: 10.1080/14615517.2012.706943

RENEWABLE ENERGY COMMUNITIES: CONCEPTS, APPROACHES AND THE CASE STUDY OF TELHEIRAS NEIGHBORHOOD IN LISBON

Evandro Ferreira[1], João Pedro Gouveia[2], Miguel Macias Sequeira[3]

1NOVA School of Science and Technology, NOVA University Lisbon, Campus de Caparica, 2829-516, Caparica, Portugal, ec.ferreira@campus.fct.unl.pt
2CENSE – Center for Environmental and Sustainability Research & CHANGE - Global Change and Sustainability Institute, NOVA School of Science and Technology, NOVA University Lisbon, Campus de Caparica, 2829-516, Caparica, Portugal, jplg@fct.unl.pt
3CENSE – Center for Environmental and Sustainability Research & CHANGE - Global Change and Sustainability Institute, NOVA School of Science and Technology, NOVA University Lisbon, Campus de Caparica, 2829-516, Caparica, Portugal, m.sequeira@campus.fct.unl.pt

Abstract
Collective energy initiatives as Renewable Energy Communities (RECs) play a key role in reducing energy poverty and increasing energy citizenship, associated with various economic, social, and financial benefits for the locals. This paper aims to present a broad view of the concept of a REC focused on the European context, also systematizing a set of study cases to uncover key activities, technologies, advantages, and challenges of implementing this energy entity. In this context, a real world study case is explored in detail through the Telheiras REC development, where the implementation process was followed and is reported, and key outputs include photovoltaic simulations carried out in six buildings of the community.

Keywords: renewable energy community, energy poverty, energy transition, energy democracy, renewable energy, solar photovoltaic.

1 INTRODUCTION
The energy transition towards renewable energy sources, reduction of global warming effects, and achievement of sustainable development are some of the most important goals of this century. In this scenario of various climate agreements and objectives, citizen participation is an important pillar for the transition, where energy collective actions – such as Renewable Energy Communities (RECs) – play a keyhole in translating the needs of the population regarding energy and reducing energy poverty and vulnerability, where no citizen should be left out of this transition process, making it increasingly fair and democratic.
The main objective of this paper is to provide a study about RECs and the link between these energy organizations, energy poverty and energy citizenship, based on the real case of Telheiras REC.

2 METHODOLOGY
After a study and literature review about energy poverty, energy citizenship and RECs, a global analysis of these initial concepts and their interconnections is done, as the obtained results focus on how a REC can reduce energy poverty and enhance energy citizenship of its members. Then, the study case of Telheiras is analyzed, focusing on the implementation process – biggest challenges and the associated solutions – and how this energy organization acts on the local community, as well as six photovoltaic simulations for evaluating the potential of local renewable energy generation.

3 RESULTS AND DISCUSSION

3.1. Impact of RECs on the reduction of energy poverty (possibilities)

- Profits of the microgrid systems: surplus reached after the payback time of the systems can be utilised on workshops on energy efficiency, reduction of energy bills of the members and enhancement of energy literacy.
- Partnerships with the municipality: possibility of subsides on energy tariffs, higher energy security and reliability, enhancement of energy local actions provided by local authorities.

- Energy storage and flexibility: a REC can be associated with energy storage systems and energy flexibility practices, avoiding higher consumption on peak hours, and promoting reduction on energy bills.

3.2. Impact of RECs on the enhancement of energy citizenship (possibilities)

- Enhancement of energy literacy: a REC can provide sessions and events to discuss simple energy efficiency practices for the local community, enhance their conscience about climate change and their hole in the transition and helping the citizens to understand their energy needs (citizens not only as simple consumers, but as active players in the transitions).
- Increase on the acceptance of renewables: a REC can be the link between renewable energy systems and the population, enhancing the acceptance of clean energy and promoting the creation of local jobs and companies associated with these systems.
- Raise awareness about citizen participation in the transition: the REC is a proof of how important the citizen participation is to achieve the climate goals and objectives, even though many citizens still believe that this responsibility rests solely on the shoulders of local governments and authorities. A REC can also be seen as a way of translating the real needs of the local citizens can impact the local energy decisions.

3.3. Study Case: Telheiras REC

Telheiras REC faces important challenges during its implementation process, such as:
- Lack of knowledge about RECs by local governments (solution: constant participation in local events and a well-designed communication plan).
- Maintenance of engagement and proactivity of the voluntary citizens (solution: strong leadership figure).
- Authorization for the use of roof area of public buildings for photovoltaic systems (solution: partnerships with important authorities).
- Elaboration of a financing scheme (solution: partnerships with experts, as FCT-NOVA, Coopérnico and Energy Poverty Advisory Hub).

As the scheme includes social members and enhancement of energy literacy regarding household energy efficiency, Telheiras REC acts directly towards the reduction of local energy poverty, where the members will face lower energy bills based on renewable energy and higher knowledge about their energy needs, helping the most vulnerable ones to enhance the comfort inside their homes.
Regarding the photovoltaic systems, the six evaluated buildings are way more than enough to reach the generation for the pilot project, as the REC has complete conditions for starting its licensing phase.

REFERENCES
Chevalier, J.-M. (2009). The new energy crisis. The New Energy Crisis (6-59). Palgrave Macmillan UK. https://doi.org/10.1057/9780230242234_2
DellaValle, N., & Czako, V. (2022). Empowering energy citizenship amont the energy poor. Energy Research & Social Science, 89 (102654), 102654. https://doi.org/10.1016/j.erss.2022.102654.
Gui, E.M., & MacGill, I. (2018). Typology of future clean energy communities: An exploratory structure, opportunities, and challenges. Energy Research & Social Science, 35, 94-107. https://doi.org/10.1016/j.erss.2017.10.019.

CONSUMERS SWITCHING INTENTION AMONG ELECTRICITY SUPPLIERS: A PUSH-PULL-MOORING MODEL

Fábio Vieira[1], Mónica Meireles[2], Graça Trindade[3]

[1]Iscte – Instituto Universitário de Lisboa (PORTUGAL), Fabio_Marcelo_Vieira@iscte-iul.pt
[2] Iscte – Instituto Universitário de Lisboa (PORTUGAL), Business Research Unit (bru_iscte), Department of Economics, monica.meireles@iscte-iul.pt
[3] Iscte – Instituto Universitário de Lisboa (PORTUGAL), Business Research Unit (bru_iscte), Department of Quantitative Methods for Management and Economics, graca.trindade@iscte-iul.pt

Abstract

The liberalization process of the Portuguese electricity market, which started in the 1990s, is integrated in the strategic action enacted by the European Union (EU). However, the benefits of this process are not clear. Even though electricity, *per se*, is a homogeneous product, over the years its commercialization has been conducted together with other products and complementary services to create product differentiation. This implies that consumers may not have felt the reduction in prices due to the higher retail costs of traders. Another aspect that can lead consumers not to benefit from this process relates with their own little involvement in the market. In 2018, according to Eurostat data, Portuguese households paid the fourth highest value in the EU per kilowatt-hour (kWh) of electricity, despite registering a 16% switching rate in electricity suppliers. With the introduction of competition in the electricity sector, it became essential for electricity providers to identify the factors that determine consumers' choice and switching between electricity suppliers. This study intends to apply the push-pull-mooring migration theory to consumers in the electricity market to understand the switching behavior between suppliers. The results from this model allow helping both market players and public policy makers designing strategies and incentives aligned with consumer behavior.

Keywords: Retail electricity market liberalization, Consumer switching behavior, Push-Pull-Mooring framework.

1. Introduction

With the success of liberalization of the telecommunication sector, the European Commission extended the principles of the free market to the energy sector (Newbery, 2002), whose main objective was to introduce competition to foster efficiency. However, despite the benefits of this process in the telecommunication sector, in the energy sector they have not been so clear. Even though electricity, *per se*, is a homogeneous product, over the years its commercialization has been conducted together with other products (e.g., natural gas) and complementary services (e.g., technical assistance, mobility solutions and even smart equipment) to create product differentiation. This implies that consumers may not have felt the reduction in prices due to the higher retail costs of traders. Another aspect that can lead consumers not to benefit from this process relates with their own little involvement in the market (Gamble et al., 2009).

The British Competition and Markets Authority (CMA) notes that consumers in the energy market lost an average of £ 1.4 billion between 2012-2015 due to the low switching rate. The liberalization process in Japan shows high resistance to change between suppliers (Shin and Managi, 2017). In Denmark, despite the smooth functioning of the market, there is little consumer involvement (Yang, 2014). Although the switching rate is not the only indicator to reflect the success of liberalization process, it is useful to achieve sector reform objectives (Shin and Managi, 2017). However, promoting the involvement of all consumers in the market might be economically inefficient due to the switching costs (Ek and Söderholm, 2008).

In 2018, according to Eurostat data, Portuguese households paid the fourth highest value in the EU per kilowatt-hour (kWh) of electricity, despite registering a 16% switching rate in electricity suppliers (ERSE, 2018a). In 2021, this switching rate was 17%, maintaining the tendency for high intensity rates of change (ERSE, 2022). These results might be explained by the fact that the Portuguese market is still highly concentrated. At the end of 2022, around 74% of the customers were still supplied by the incumbent (ERSE, 2023).

With the introduction of competition in the electricity sector, it became essential for electricity providers to identify the factors that determine consumers' choice and switching between electricity suppliers. Therefore, this study intends to apply the push-pull-mooring migration theory to consumers in the electricity market to understand the switching behavior between suppliers. This framework describes the negative factors driving users away from their current supplier (push effect) and the positive factors attracting users towards the competitors (pull effect), as well as the personal characteristics (mooring effect) that either hamper or facilitate the switching intention. To the best of our knowledge, no empirical research, in the electricity sector, has dealt with this model and relatively few studies have been conducted to explore the switching behavior of electricity consumers. Therefore, this study seeks to answer the following question: What are the push-pull-mooring effects in the switching behavior of the Portuguese electricity consumers?

The remainder of this paper is as follows. In the next section a literature review is presented. Then the data and methodology are explained. Section 4 highlights the main results. Finally, section 5 concludes with the main contributions addressing some considerations for market players and public policy makers to help designing strategies and incentives aligned with consumer behavior, considering both economic and psychological factors and their combined effect in their switching intention.

2. Literature review

Portugal followed closely the restructuring process initiated by the EU, undergoing two major legal and structural changes towards a liberalized system. In 1995, anticipating the 96/92/EC directive, the vertically integrated state-owned monopoly was legally unbundled from wholesale to the retail segment and converted into a dual system, the "regulated" and the "free market" systems operating simultaneously. The wholesale was liberalized and the retail was partially opened to competition. In contrast, transmission and distribution activities remained regulated to allow producers the access on a non-discriminatory basis to these segments. In 2006, this dual regime was replaced by the "free market" approach, in compliance with the 2003/54/EC directive and it was created the last resort supplier. These profound changes in the national electricity sector were combined with other EU energy policies towards carbon trading in 2005, the 2020 renewable electricity and energy security and efficiency. Contrary to the wholesale market, the retail market has been opened gradually, starting from large industrial consumers, and extending to smaller consumers. The phasing-out of the regulated retail tariffs, which was initially planned for 2015 and now scheduled for the end of 2025 by the Law 2/2020 of March, 21 forces consumers to switch from the last resort supplier to the liberalized market suppliers and promotes the entrance of new companies (Ghazvini et al., 2016). During this transition period, consumers can more easily compare and evaluate offers of alternative electricity providers and therefore, switch between suppliers. In the retail electricity market, the product offered to customers is homogeneous, which focus competition on price. Consequently, to make it difficult for consumers to compare prices, retailers have been offering additional differentiated services as dual fuel contracts, flexible billing (variable and fixed rates), green energy, among others. In Portugal the incumbent, EDP Comercial, still owns a high market share – 72% (ERSE, 2023). Although the switching rate is high, many residential consumers are still being supplied by the incumbent, which can be explained by the fact that the switching rate considers not only the changes within the LM, but also the new consumers and those that left the regulated market to enter in the LM. Furthermore, most consumers have a long-established relationship with EDP Comercial, which might result in a great willingness to sign contracts with this company after the removal of regulated tariffs. Therefore, it is crucial to study the determining factors that lead the electricity customers to switch from the incumbent service to alternatives. To have a clearer view of the potential of retail market liberalization it is essential to evaluate consumer's behavior.

In the literature it can be found several studies analyzing the reasons behind the consumers intentions to change. However, Bansal et al. (2005) were the first to apply the push-pull-mooring model to understand consumer's switching behavior for the case of hairstyling and car repair services. According to them the decision to change supplier depends on three factors:

- **Push effect** - characteristics of the current firm that motivate the consumer to change to other firms, namely: (1) quality; (2) satisfaction; (3) value; (4) trust; (5) commitment and (6) price perception;
- **Pull effect** - characteristics of the other market traders that attract the consumer to them. It represents the attractiveness of the alternatives;
- **Mooring effect** - intrinsic characteristics of each consumer that allows revealing themselves, acting as a moderating effect, inhibiting or enhancing the Push and Pull effects, which are: (1) attitudes toward switching; (2) social norms; (3) switching costs; (4) past experience in switching, and (5) variety-seeking tendencies.

Since the work of Bansal et al. (2005), the push-pull-mooring model has been extended to other services. For instance, Zhang et al. (2008) studied consumers' switching intention for blog service providers and Hou et al. (2011) applied the model to the online role-playing game services. More recently, Jung et al. (2017) explored the key determinants of travelers' switching intention in terms of airline selection and Sun et al. (2017) examined the main factors influencing users' switching intention in the mobile instant messaging.

3. Data and methodology

Following Bansal et al. (2005), a similar model was developed to study the intention to change of the Portuguese electricity consumers. For this analysis three dimensions were stressed: (1) satisfaction, value, trust, and commitment to the supplier, as well as the perception of the charged prices; (2) attitudes toward switching, the costs of switching, the variety-seeking dependency, the subjective norms (social influence) and previous purchase behavior, and (3) the attractiveness of competitors.

Therefore, this paper intends to investigate whether the factors considered as mooring effects moderate the relationship between the independent variables - perceptions of the push and pull factors -, and the dependent variable - the intention to change - to contribute to the validation of the following hypotheses:

- H1: Mooring factors moderate the relationship between the perception of the characteristics of the current supplier (push effects) and the intention to change;
- H2: Mooring factors moderate the relationship between the perceived attractiveness of competitors (pull effects) and the intention to change.

To collect the data, an online survey from a non-probability convenience sampling technique was used. The questionnaire was prepared to assess the validity of the theoretical model and it was disclosed through the Google Forms platform since it allows easier construction, treatment, and export of data. The survey was available between 11 February 2022 and 15 May 2022, resulting in a total of 125 valid questionnaires.

An exploratory factor analysis in principal components with varimax rotation (orthogonal rotation) was carried out to reduce the dimensionality of the observed variables that are related to the same subject. This procedure allows the extraction of the components that are independent from each other, for the same set of items within the same subject. After extracting the components, the binary logistic regression procedure was performed to analyze whether the components of the mooring factors moderate the relationship between the components of both push and pull effects and the intention to change. The estimated model is the following:

$$Logit(p_i) = [ln(p_i/(1-p_i))]$$

$$= -2.207 + 1.014 PUSH_3 x M_2 - 1.06 PUSH_3 x M_3 + 0.701 PUSH_3 x M_5 - 0.660 PUSH_4 x M_2 +$$

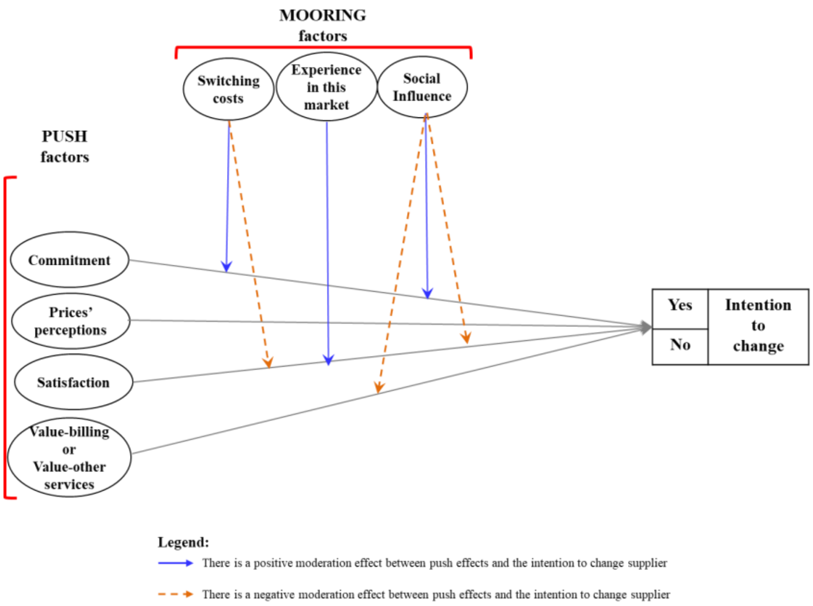
$$+ 0.532 PUSH_4 x M_3 - 0.856 PUSH_4 x M_5 - 0.808 PUSH_5 x M_5 \qquad (1)$$

Where $(p_i/(1-p_i)$ is the ratio between the probability of a choice versus the possibility of verifying the other alternative. There are seven significant effects, three positive and four negative ones.

4. Results

From the previous results, it can be concluded that hypothesis H1 (mooring factors moderate the relationship between push effects and the intention to change) is validated, whereas hypothesis H2 (mooring factors moderate the relationship between pull effects and the intention to change) is not. The estimated empirical model is depicted in Figure 1.

Figure 1: Estimated empirical model



The results suggest that the moderating effects such as the switching costs, the previous experience in this market, as well as the social influence play important roles in consumer switching intention. In general, low satisfaction, higher prices' perceptions, low commitment, and higher value-billing of the other services can push consumers away from their current electricity supplier. These findings contrast with those of Bansal et al. (2005), Hou et al. (2011) and Jung et al. (2017) that found customers' electricity switching intention is more influenced by the strengths of the other alternatives (pull variables) than the current service providers (push variables).

These findings can be of crucial importance for both market players and public policy makers. For the market players the results help them understanding the causes affecting the consumers' switching intention process. Indeed, consumers who perceive a high market price and who have a low satisfaction with the current supplier are more prone to switch to a different supplier. Accordingly, those who have a low commitment are also more prone to switch to other suppliers if they face low switching costs. Regarding public policy makers, they can leverage the positive moderation effect of past switching experience in this market, and in some similar markets, promote competition and reduce consumer inertia to benefit from the gains of a liberalized market as stated by Gamble et al. (2009). This conclusion is consistent with the findings of Shin & Managi (2017), who state that past switching in phone carriers increased the likelihood of switching in electricity market by 16%.

5. Conclusion

The success of the liberalization in the electricity sector is strongly dependent on the conditions promoting a truly competitive market, characterized by many competitors, reduced market shares and high rates of consumer switching, both in the household and industrial sectors. Therefore, it is crucial to identify and understand the determinants of electricity costumers' switching intentions towards alternative suppliers. Using the push-pull-mooring framework, this paper contributes to the study of the consumer electricity-switching behavior in the Portuguese electricity market. Although, in the literature, it can be found several studies employing this model, this paper represents the first attempt to apply the push-pull-mooring model at the electricity sector.

By collecting data through a questionnaire, this research provides insights for two main economic agents such as the market players and the public policy makers. For the market players the results help them understanding the main causes affecting consumers' switching intention process. For the policy makers

it helps designing incentives aligned with consumer behavior, considering both economic and psychological factors and their combined effect in the switching intention, instead of considering the individual impacts of each variable only, as commonly addressed in the literature.
Future research may include a larger dimension of the sample to allow a confirmatory analysis to validate the theoretical model proposed by Bansal et al. (2005). Furthermore, additional pull and mooring forces should be included in the analysis as the results of this study suggest that our understanding of electricity switching would benefit from a greater focus on those effects. Branding, reputation, novelty and environmental concerns are some examples that might influence consumers' intentions to change.

REFERENCES

Bansal, H. S., Taylor, S. F. & James, S. Y. (2005). Migrating to new service providers: Toward a unifying framework of consumers' switching behaviours. *Journal of the Academy of Marketing Science*. *1*, 96-115.
Ek, K. & Söderholm, P. (2008). Household switching behaviour between electricity suppliers in Sweden. *Utilities Policy*, *16*, 254-261.
ERSE. (2018a). *Annual report on the electricity and natural gas markets – Portuguese Energy Services Regulatory Authority*. [accessed in March, 2023]. Retrieved from https://www.erse.pt/media/4ewnhglv/relat%C3%B3rio-anual-sobre-os-mercados-de-eletricidade-e-g%C3%A1s-natural-em-2019-portugal.pdf
ERSE. (2018b). *Liberalized electricity market bulletin – Portuguese Energy Services Regulatory Authority*. [accessed in March, 2023]. Retrieved from https://www.erse.pt/media/g4rdcssk/201812_ml_dezembro-elec.pdf
ERSE. (2022). *Annual report on the electricity and natural gas markets in Portugal 2021 – Portuguese Energy Services Regulatory Authority*. [accessed in April, 2023]. Retrieved from https://www.erse.pt/media/pt0g0xp3/relatório-anual-dos-mercados-retalhistas-de-eletricidade-e-gás-em-2021-em-portugal.pdf
ERSE. (2023). *Liberalized electricity market bulletin – Portuguese Energy Services Regulatory Authority*. [accessed in April, 2023]. Retrieved from https://www.erse.pt/media/yh1jgq1v/202212_ele_rel_ml.pdf
Gamble, A., Juliusson, A.E. & Gärling, T. (2009). Consumer attitudes towards switching supplier in three deregulated markets. *The Journal of Socio-Economics*, *38*, 814-819.
Ghazvini, M., Ramos, S., Soares, J., Vale, Z. & Castro, R. (2016). Liberalization and customer behavior in the Portuguese residential retail electricity market. *Utilities Policy*, *59*, 100919.
Hou, A.C.Y., Chern, C.C., Chen, H.G, & Chen, Y.C. (2011). Migrating to a new virtual world: Exploring MMORPG switching through human migration theory. *Computer in Human Behaviour*, *27*(5), 1892-1903.
Jung, J., Han, H. & Oh, M. (2017). Travelers' switching behaviour in the airline industry from the perspective of the push-pull-mooring framework. *Tourism Management*, *59*, 139-153.
Newbery, D. (2002). Problems of liberalising the electricity industry. *European Economic Review*, *46*, 919-927.
Shin, J. K. & Managi, S. (2017). Liberalization of a retail electricity market: Consumer satisfaction and household switching behaviour in Japan. *Energy Policy*, *110*, 675-685.
Sun, Y., Liu, D., Wu, X. & Shen, X-L. (2017). Understanding users' switching behaviour of mobile instant messaging applications: An empirical study from the perspective of push-pull-mooring framework. *Computers in Human Behaviour*, *75*, 727-738.
Yang, Y. (2014). Understanding household switching behaviour in the retail electricity market. *Energy Policy*, *69*, 406-414.
Zhang, K.Z.K., Cheung, C.M.K., Lee, M.K.O. & Chen, H. (2008). Understanding the blog service switching in Hong Kong: An empirical investigation, in *The 41st annual Hawai International Conference Proceeding, System Service* (p. 269).

AN ASSESMENT OF FUEL POVERTY IN TROPICAL TERRITORY: CASE OF LA REUNION

Manitra Rakotomena[1], Olivia Ricci[2]

[1] *CEMOI, University of La Réunion (FRANCE), andriandrazana.rakotomena@univ-reunion.fr*
[2] *CEMOI, University of La Réunion (FRANCE), olivia.ricci@univ-reunion.fr*

Abstract

Fuel poverty is a growing phenomenon. In this study, our objective is to provide a new way to better identify those who suffer the most from fuel poverty whether the live in cold or hot weather countries. Drawing on the indicator developed by Charlier and Legendre (2019) by including climatic comfort, we recommend using a multidimensional approach to measure fuel poverty in tropical territories, through monetary poverty, quality of dwelling and thermal discomfort. Our indicator shows that usual measures do not consider all dimensions of the phenomenon and exclude those who are at or above a certain threshold, but may be vulnerable.

Keywords: Fuel poverty, tropical territories, multidimensional approach, quality of housing, thermal discomfort

CONCLUSION

Fuel poverty is an increasingly serious problem in temperate regions as well as in tropical territories. Several indicators exist to measure the phenomenon but none specific to tropical territories. This study aims to provide a new way to better identify households who suffer the most from fuel poverty whether they live in cold or hot weather countries. A multidimensional approach of fuel poverty based on monetary poverty, building quality and climatic conditions and comfort provides better understanding and measure. The tropical fuel poverty index provides a scale of fuel poverty, rather than simply defining households as fuel poor or not. It can help policymakers the possibility of choosing which population at which ranges of the TFPI need to be targeted with specific policies. Finally, the TFPI can be used to make comparison over time and among countries.

ANALYSIS OF FINANCING SCHEMES TARGETING ENERGY EFFICIENCY AND ENERGY POVERTY MITIGATION IN THE EUROPEAN UNION, UK, AUSTRALIA AND NEW ZEALAND

Bárbara Fernandes[1], João Pedro Gouveia[2]

[1]NOVA School of Science and Technology, NOVA University Lisbon, Campus de Caparica, 2829-516, Caparica,Portugal, bal.fernandes@campus.fct.unl.pt
[2] CENSE – Center for Environmental and Sustainability Research & CHANGE - Global Change and Sustainability Institute, NOVA School of Science and Technology, NOVA University Lisbon, Campus de Caparica, 2829-516, Caparica, Portugal, jplg@fct.unl.pt

1. Introduction

With the Kyoto Protocol in 1997 and the adoption of the Paris Agreement at COP 21 in 2015, climate change has been recognised as one of the most critical and urgent issues of our time. Limiting global temperatures to below 2°C above pre-industrial levels was a major milestone in negotiations that ultimately defined a global plan to mitigate the effects of climate change. The main objective of the Paris Agreement is to peak greenhouse gas emissions (GHG) as soon as possible and balance their emissions with their removal by sinks (Bertoldi *et al.*, 2021; Della Valle & Bertoldi, 2022; Economidou *et al.*, 2020). Energy production and consumption significantly impact climate change through their contributions to CO2 emissions. In the European Union (EU), energy production and use account for 80% of total GHG. Although the building sector accounts for 40% of the final energy and 36% of emissions in the EU, with the residential sector accounting for approximately 25% of emissions, it is considered one of the sectors with the most significant potential for energy savings (Bertoldi *et al.*, 2021; Economidou *et al.*, 2020).
According to the IPCC Special Report on 1.5ºC, energy efficiency (EE) and building renovation are two key points to achieve carbon neutrality while bringing many benefits, such as reducing urban pollution and reducing energy poverty for the population (Bertoldi *et al.*, 2021; Della Valle & Bertoldi, 2022).
The concept of energy poverty (*i.e.*, fuel poverty in the UK) emerged in England in 1973 as a result of an energy crisis in which energy prices rose to levels that families could not afford. In the 1980s, the term 'fuel poverty' was established. Still, it was not until 1991 that the first official definition was established in the UK: "Fuel poverty is the inability of a household to obtain adequate energy services (in the home) for 10% of its income". Today, the European Commission defines energy poverty as "a situation where households lack access to essential energy services and products." Energy poverty occurs when energy bills represent a high percentage of consumers' income or when they have to reduce their household's energy consumption to the extent that negatively affects their health and well-being. In the EU, the context of current energy poverty is diverse due to its multidimensionality of drivers and regional differences. According to a Europe-wide survey conducted in 2020, 8% of the European population reported that they were unable to keep their homes adequately warm. (European Commission, 2023; Eurostat, 2021 Kyprianou *et al.,* 2019; Ramos *et al*., 2022).The countries in which this problem was most common were Bulgaria (23.7%), Lithuania (22.5%), Cyprus (19.4%), Greece (17.5%) and Portugal, (16.4%) (EPAH, 2023).
Nevertheless, many policies have been developed and implemented over the years to increase buildings' energy efficiency and fight energy poverty. In 2019, the Clean Energy Package was adopted for all Europeans. As part of their commitment to fighting energy poverty, European countries had to draw up their National Energy and Climate Plans, integrating different measures, definitions of the concept and solutions, and methods to monitor the situation in the country. In 2020, a Recommendation on Energy Poverty was launched to support local governments on this issue, of which the Renovation Wave is an integral part. This provides a guide for appropriate indicators to measure energy poverty in each country and promote the exchange of best practices between Member States (European Commission, 2023).
The Fit for 55 package was another measure adopted in July 2021. It proposes specific actions to identify the main drivers of energy poverty risks for consumers, such as high-energy prices, low household income, and low energy efficiency of buildings (European Commission, 2023).
By adopting appropriate policy solutions, governments can support the renovation of buildings and develop energy-efficient markets. Financial and fiscal instruments play an essential role in many countries as they can help financially constrained households undertake energy renovations and remove various financial barriers that may exist. Given the low share of new buildings, renovation of existing buildings is

the best solution to achieve carbon neutrality in this sector. Policies supporting energy efficiency include the Energy Performance of Buildings Directive (EU) 2018/844 and the revised Energy Efficiency Directive (EU) 2018/2022. EU structural and investment funds, such as the European Regional Development Fund, European Social Fund, and Cohesion Fund, are funds that support energy projects and financial instruments implemented in European countries (Bertoldi *et al*., 2021; European Commission, 2023; Kyprianou *et al*., 2019). The main objective of this study is to explore and compare financial instruments to tackle energy poverty and/or promote energy efficiency in residential buildings in the EU, UK, Australia, and New Zealand to understand which are the best features and successful cases to further applications.

2. Methodology

The methodology used herein comprises three main phases. In the first phase, experts in the field of energy poverty/building renovation were selected from several of the countries in the study areas based on their experience in the topic of energy poverty and energy efficiency. In the second phase, the selected experts were subjected to an email interview in which they described the financing schemes implemented in their countries at the national and/or regional level. At this stage, all the information collected in the interviews was analysed and then used for the third stage of the methodology. In this phase, the funding schemes described by the experts were characterized and assessed to identify the best-implemented models and their effectiveness and efficiency. Simultaneously, a qualitative method called “Snowball Sampling” was used. This method is used when the intended sample is not easily accessible because it is a purposive data collection method. This method was used to gather additional information on these countries' financing programmes and energy policies (Naderifar *et al.*, 2017).

3. Results

This section discusses the results obtained thus far. Initially, 23 emails were sent to experts from different countries, and this number increased to approximately 40 emails over the course of the study to 25 countries. After completing the first two phases of the methodology, information on 23 countries and 35 financial support schemes was collected. The countries with the highest number of schemes are Portugal ((FA, 2021, 2022)), Spain (IDAE, 2015), Poland, Italy(Agenzia Entrate, 2023; ENEA, 2019), France, Ireland (Citizens Information Board, 2022; IEA, 2022), Scotland, Croatia, and New Zealand (EECA, 2023), as shown in Figures 1 and 2.

Figure 1 - Number of funding schemes by country in the EU and UK.

Figure 2 - Number of funding schemes by country in New Zealand and Australia.

Of all the schemes collected, 61% are focused on promoting energy efficiency, whereas only 33% are focused on tackling energy poverty. The remaining programmes were hybrid, combining both concepts in a single programme. The vast majority operate in the form of grants and loans, with the exception of some

programmes, such as Vale Eficiência in Portugal and the Better Energy Warmer Homes Scheme (BEWHS) in Ireland, where payment is made directly to the supplier/contracting company (FA, 2021; Midland Warmer Homes, 2021).
In specific energy poverty programmes, the target group are vulnerable energy consumers, identified according to the rules of the country concerned. In terms of building typology, energy poverty programmes tend to target pre-2010s buildings for renovation. These typologies focus on heating and cooling systems, insulation, windows replacement, and ventilation improvements. In these programmes, funding for families is usually 100% of the cost of the intervention, subject to a maximum ceiling.
Unlike energy poverty programmes, energy efficiency financing programmes cover the entire population. The year of construction of the buildings included in the programme usually takes into account the measures to be implemented. An example is the Irish Better Energy Homes Scheme (BEH) programme, in which eligible dwellings can only be implemented before 2021 if the intervention is the installation of solar panels for energy production. The type of dwelling also varies between single-family houses, autonomous fractions, and multi-family houses; the average financing value for families is 50%, and some programmes can reach 110% financing, as in the case of the Italian Superbonus 110% programme. In energy efficiency financing schemes, the most common typologies are the same as those in energy poverty programmes, with the addition of solar panels, entrance doors, lighting, solar shading, electric vehicle chargers, and structural anti-seismic measures. In all programmes, applicants must own their homes or have permission from the landlord to carry out the work (e.g. Agenzia Entrate, 2023; Citizens Information Board, 2022).

4. Conclusions

A diversity of countries worldwide are increasingly establishing energy efficiency/energy poverty schemes. To make funding schemes more efficient towards the goals of carbon neutrality in the sector, this study aims to analyse the functioning and effectiveness of programmes around the world and explore possibilities for improvement. It also aims to provide tools to help national governments identify the most vulnerable consumers, improve their housing conditions, reduce their energy bills, and improve their quality through measures and solutions that are more relevant to the problem and attractive to the population.
Both the EU and the other studied countries have significant challenges ahead to promote deep energy renovations, reduce energy poverty and increase energy efficiency in their homes. There are many programs that provide the opportunity for families to incorporate EE measures into their dwellings. However, renovations are uncommon and do not reach desired levels. This highlights the need to increase the number of renovations and to make them more complete in terms of the interventions performed (Bertoldi *et al.*, 2021). On the other hand, this may increase the funding schemes transaction costs and the interest/difficulty of households to implement them.

REFERENCES

Agenzia Entrate. (2023). *Superbonus 110%*. Ministero dell'Economia e delle finanze. Roma. Italia. Retrieved in March 2023, from https://www.agenziaentrate.gov.it/portale/web/guest/superbonus-110%25
Bertoldi, P., Economidou, M., Palermo, V., Boza-Kiss, B., & Todeschi, V. (2021). How to finance energy renovation of residential buildings: Review of current and emerging financing instruments in the EU. In *Wiley Interdisciplinary Reviews: Energy and Environment* (Vol. 10, Issue 1). John Wiley and Sons Ltd. https://doi.org/10.1002/wene.384
Citizens Information Board. (2022). *Individual home energy upgrade grants (Better Energy Homes)*. Sustainable Energy Authority of Ireland. Ireland. Retrieved in March 2023, from https://www.citizensinformation.ie/en/housing/housing_grants_and_schemes/home_energy_saving_scheme.html
Della Valle, N., & Bertoldi, P. (2022). Promoting Energy Efficiency: Barriers, Societal Needs and Policies. *Frontiers in Energy Research*, *9*. https://doi.org/10.3389/fenrg.2021.804091
Economidou, M., Todeschi, V., Bertoldi, P., D'Agostino, D., Zangheri, P., & Castellazzi, L. (2020). Review of 50 years of EU energy efficiency policies for buildings. In *Energy and Buildings* (Vol. 225). Elsevier Ltd. https://doi.org/10.1016/j.enbuild.2020.110322
EECA. (2023). *Warmer Kiwi Homes programme*. Energy Efficiency & Conservation Authority. New Zealand Government. New Zealand. Retrieved in March 2023, from https://www.eeca.govt.nz/co-funding/insulation-and-heater-grants/warmer-kiwi-homes-programme/

ENEA. (2019). *Ecobonus*. Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile. Dipartimento unità per l'efficienza energetica. Roma. Italia. Retrieved in March 2023, from https://www.efficienzaenergetica.enea.it/detrazioni-fiscali/ecobonus.html

EPAH. (2023). *National indicators*. Energy Poverty Advisory Hub. Directorate-General for Energy. European Commission. Retrieved in March 2023, from https://energy-poverty.ec.europa.eu/observing-energy-poverty/national-indicators_en

European Commission. (2023). *Energy poverty in the EU*. Energy. Directorate-General for Energy. Retrieved in March 2023, from https://energy.ec.europa.eu/topics/markets-and-consumers/energy-consumer-rights/energy-poverty-eu_en

Eurostat. (2021). *8% of EU population unable to keep home adequately warm*. European Union. Retrieved in March 2023, from https://ec.europa.eu/eurostat/web/products-eurostat-news/-/ddn-20211105-1

FA. (2021). *Apoio ao Programa Vale Eficiência.* Fundo Ambiental, Plano de Recuperação e Resiliência. Secretaria-Geral do Ambiente. Ministério do Ambiente e Ação Climática. República Portuguesa. Lisboa. Portugal. Retrieved in March 2023, from https://www.fundoambiental.pt/ficheiros/vales-eficiencia-pdf.aspx

FA. (2022). *01/C13-i01 - 2a FASE Programa de Apoio Edifícios + Sustentáveis*. Fundo Ambiental, Plano de Recuperação e Resiliência. Secretaria-Geral do Ambiente. Ministério do Ambiente e Ação Climática. República Portuguesa. Lisboa. Portugal. Retrieved in March 2023, from https://www.fundoambiental.pt/apoios-prr/c13-eficiencia-energetica-em-edificios/01c13-i01-paes-ii.aspx

IDAE. (2015). *Bases del Programa de Ayudas para la Rehabilitación energética de Edificios existentes (PAREER-CRECE)*. Instituto para la Diversificación y ahorro de la Energía, Ministerio para la Transición Ecológica y el Reto Demográfico . Gobierno de España. Madrid. España. Retrieved in March 2023, from https://www.idae.es/uploads/documentos/documentos_PAREER-CRECE-texto_refundido_y_consolidado_478cfff4.pdf

IEA. (2022). *National Retrofitting Scheme*. International Energy Agency. Retrieved in March 2023, from https://www.iea.org/policies/15962-national-retrofitting-scheme

Kyprianou, I., Serghides, D. K., Varo, A., Gouveia, J. P., Kopeva, D., & Murauskaite, L. (2019). Energy poverty policies and measures in 5 EU countries: A comparative study. *Energy and Buildings*, *196*, 46–60. https://doi.org/10.1016/j.enbuild.2019.05.003

Midland Warmer Homes. (2021). *Better Energy Warmer Homes Scheme Process*. Ireland. Retrieved in March 2023, from https://www.midlandwarmerhomes.ie/bewhs/#1572005079593-c4849099-3006

Naderifar, M., Goli, H., & Ghaljaie, F. (2017). Snowball Sampling: A Purposeful Method of Sampling in Qualitative Research. *Strides in Development of Medical Education*, *14*(3). https://doi.org/10.5812/sdme.67670

Ramos, C., Alvargonzález, M., & Moreno, B. (2022). Study of energy poverty in the European Union: the effect of distributed generation. *Energy Sources, Part B: Economics, Planning and Policy*, *17*(1). https://doi.org/10.1080/15567249.2021.2018525

Resolución de 6 de marzo de 2017, del consejo de Administración del Instituto para la Diversificación y Ahorro De La Energía, por la que se establecen las Bases Reguladoras de da Segunda Convocatoria del Programa de Ayudas para Actuaciones de Rehabilitación Energética de Edificios Existentes (PAREER II).

EXPLORING ENERGY POVERTY AND THERMAL COMFORT IN UPPER SECONDARY STUDENTS: A CASE STUDY OF LISBON, PORTUGAL

Inês Valente[1], João Pedro Gouveia[2]

[1]*NOVA School of Science and Technology, NOVA University Lisbon (PORTUGAL),* *imo.valente@campus.fct.unl.pt*

[2] *CENSE – Center for Environmental and Sustainability Research & CHANGE - Global Change and Sustainability Institute, NOVA School of Science and Technology, NOVA University Lisbon, Campus de Caparica, 2829-516, Caparica, Portugal,* *jplg@fct.unl.pt*

Keywords: Thermal Comfort, Energy Poverty, School Buildings, Lisbon.

1. INTRODUCTION

Energy poverty is a growing multidimensional concern worldwide, with children and young people among the groups particularly vulnerable (Teariki et al., 2020; Zhang et al., 2021; Middlemiss, 2022). This vulnerability is often associated with negative impacts on their physical and mental health (Harker, 2006; Bhattacharya et al., 2003; Geddes et al., 2011; Mohan et al., 2021, Oliveira et al., 2021). Despite this population group spending a significant amount of time in their houses and school buildings (EC, 2003; OCDE, 2019), there has been little research on the dual vulnerability to inadequate thermal comfort conditions in these two environments. In this work, the chosen case study is Portugal, top-ranked as one the EU countries with higher levels of energy poverty vulnerability (Eurostat, 2021) and where the exposure to inadequate thermal comfort in school buildings varies due to disparities in renovation efforts: while some schools have undergone renovations to improve thermal comfort, others have not. This work aims to assess upper secondary school (ages 15-18) students´ perception of energy poverty at home and thermal comfort inside classrooms.

2. METHODOLOGY

The study employed two complementary components: 1) surveys of students regarding their dwellings´ conditions and thermal comfort at home, classroom thermal comfort, and their coping strategies to deal with thermal discomfort, and 2) Interviews and surveys with other stakeholders, such as teachers, to understand their perception of this issue. Considering the unequal school renovations and the possible impact on thermal comfort, this methodology was applied in two schools: renovated (RS) and non-renovated (NRS).

3. RESULTS AND DISCUSSION

Analysing and comparing the results obtained regarding the dwelling conditions, both samples of students revealed similar results: approximately 16% of students admitted not feeling comfortable in their home during summer and 17% during winter. 4% admitted not feeling comfortable during both seasons. 42% of students identified having problems with dampness or mould in their dwellings. The percentage of equipment was higher than the national average since only 10% admitted not having heating equipment and 19% not having cooling equipment (According to Survey on Energy Consumption in Households, 18.4% of households do not have heating equipment, and 67.3% do not have cooling equipment (INE & DGEG, 2020)). To evaluate the comfort in the classroom, students were requested to respond on a seven-point thermal sensation scale ranging from “Hot” to “Cold”. The level of discomfort was subsequently classified as a percentage of students who selected “Hot”, “Warm”, “Cool” or “Cold”. The results demonstrated differences in the thermal comfort in the classroom between the two schools: students in the NRS reported higher levels of discomfort (82% and 57% during summer and winter, respectively), but the votes on RS were higher than excepted (52% and 39% during summer and winter, respectively). Further examination of these results revealed that the level of discomfort in the NRS is more severe, as 37% perceived the temperature as “hot” and 16.9% as “cold”. In contrast, only 14% and 7.2% of RS students characterized their classrooms as “hot” and “cold”, respectively.

A comparison between the students' and teachers' surveys provided insight into this phenomenon. In the NRS, discomfort may be attributed to inadequate infrastructure to provide thermal comfort, such as thermal insulation or climatization. Conversely, discomfort in the RS may be related to restrictions on the use of climatization systems or to the malfunctioning of such systems. This is supported by students reporting that some air conditioning units were not operational or that teachers were unwilling to turn on the air conditioning when requested. Another plausible explanation is the possibility of teachers' preferences overriding students' thermal needs. Most teachers described classroom temperatures as comfortable. This issue is compounded by the fact that 6-10% of students reported taking no action when uncomfortable, underscoring the urgency of addressing this problem.
To further investigate the double vulnerability, students were asked to compare thermal comfort at home and at school. Results indicate that approximately 6% of students were uncomfortable in both locations. It was also observed that more students in the RS reported feeling more comfortable at school than at home, suggesting that schools equipped with appropriate thermal comfort may serve as a refuge from energy poverty for this age group by providing the thermal comfort environment not found at their home.

4. CONCLUSIONS

The findings of this study suggest that, in addition to renovating school facilities, it is crucial to involve students in the decision process regarding classroom temperature to ensure comfort for all. Implementing these measures may increase students' motivation to attend school (approximately 60% of students identified classroom temperature as an important factor influencing their attention in class and academic achievement). This study provides valuable insights into the issue of energy poverty among young people and proves the importance of including them in policies that aim to tackle it. This study also suggests the potential for expanding the definition of energy poverty beyond the residential sector since the factors contributing to energy poverty in the residential sector, such as low energy performance, high energy prices, and external pressure to limit spending on heating and cooling, may also be observed in other sectors, including education. The findings of this study present opportunities for further exploration of the topic since the results indicate discomfort in a region with a temperate climate, it is possible that in regions of Portugal with more extreme weather conditions, higher vulnerability to energy poverty, and lack of school renovation may exhibit even more pronounced manifestations of this issue.

REFERENCES

Bhattacharya, J., Deleire, T., Haider, S., & Currie, J. (2003). Heat or Eat? Cold-Weather Shocks and Nutrition in Poor American Families. *American Journal of Public 93 (7) 1149-1154* https://doi.org/10.2105%2Fajph.93.7.1149
EC. (2021). *8% of EU population unable to keep home adequately warm*. European Commission. Retrieved in 25/01/2023 from https://ec.europa.eu/eurostat/web/products-eurostat-news/-/ddn-20211105-1
EC. (2003). *Indoor air pollution: new EU research reveals higher risks than previously thought*. Europen Commision. Retrieved 06/02/2023 from https://ec.europa.eu/commission/presscorner/detail/en/IP_03_1278
Geddes, I., Bloomer, E., Allen, J. & Goldblatt, P. (2011). *The Health Impacts of Cold Homes and Fuel Poverty.* Retrieved from *https://www.instituteofhealthequity.org/resources-reports/the-health-impacts-of-cold-homes-and-fuel-poverty/the-health-impacts-of-cold-homes-and-fuel-poverty.pdf*
Harker, L. (2006). *Chance of a lifetime The impact of bad housing on children's lives.* https://assets.ctfassets.net/6sxvmndnpn0s/4LTXp3mya7IigRmNG8x9KK/6922b5a4c6ea756ea94da71ebdc001a5/Chance_of_a_Lifetime.pdf
INE & DGEG. (2020). *Inquérito ao Consumo de Energia no Setor Doméstico 2020.* Instituto Nacional de Estatística and Direção-Geral de Energia e Geologia. Retrieved from https://www.dgeg.gov.pt/media/jvfgkejh/dgeg-aou-icesd-2020.pdf
Middlemiss, L. (2022). Who is vulnerable to energy poverty in the Global North, and what is their experience? *Wiley Interdisciplinary Reviews: Energy and Environment*, *11*(6). https://doi.org/10.1002/wene.455
Mohan, G. (2021). Young, poor, and sick: The public health threat of energy poverty for children in Ireland. *Energy Research and Social Science*, *71*. https://doi.org/10.1016/j.erss.2020.101822
OECD. (2019). *"How much time do students spend in the classroom?",* in Education at a Glance 2019: OECD Indicators, OECD Publishing. https://doi.org/10.1787/6ec208bd-en
Oliveras, L., Borrell, C., González-Pijuan, I., Gotsens, M., López, M. J., Palència, L., Artazcoz, L., & Marí-Dell'olmo, M. (2021). The association of energy poverty with health and wellbeing in children in a

mediterranean city. *International Journal of Environmental Research and Public Health*, *18*(11). https://doi.org/10.3390/ijerph18115961

Teariki, M. A., Tiatia, R., O'Sullivan, K., Puloka, V., Signal, L., Shearer, I., & Howden-Chapman, P. (2020). Beyond home: Exploring energy poverty among youth in four diverse Pacific Island states. *Energy Research and Social Science*, *70*. https://doi.org/10.1016/j.erss.2020.101638

STUDENTS' PERCEPTION OF ENERGY POVERTY— COMPARATIVE ANALYSIS AMONG CITIES IN DIFFERENT COUNTRIES AND AMONG REGIONS IN PORTUGAL

Carolina Cruz Castro[1], João Pedro Gouveia[2]

[1]NOVA School of Science and Technology, NOVA University Lisbon, Campus de Caparica, 2829-516, Caparica (Portugal), cc.castro@campus.fct.unl.pt

2CENSE - Center for Environmental and Sustainability Research & CHANGE - Global Change and Sustainability Institute, NOVA School of Science and Technology, NOVA University Lisbon, Campus de Caparica, 2829-516, Caparica (Portugal), jplg@fct.unl.pt

Energy Poverty (EP) is acknowledged as a set of conditions where "individuals or households are not able to adequately heat/cool or provide other required energy services in their homes at affordable cost" (European Commission, 2022), and it is a growing concern in EU and national policies. Students are considered to be at high risk of falling into EP (Healy et al., 2003), but this is an under-reported and under-supported group (Morris & Genovese, 2018), and limited research has been conducted on the perception of EP and vulnerability to EP of this group.

Although there are some studies that compare the perceptions of students from various countries to EP in Europe and South America, this study aims to analyze and compare university students' perceptions of EP and explores their vulnerability to EP, discussing the potential differences between three cities (Montevideo, Lisbon and Padua), two students' profiles (local vs exchange), and two seasons (winter or summer).

Additionally, a second study was carried out to investigate more deeply the perception and vulnerability of Lisbon students and students from other Portuguese regions (NUTS III) to EP. By comparing the situation between regions of this country and between the type of student (local or displaced), we aim to capture the perception and vulnerability to EP of higher education students living in Portugal.

In the first study, two types of populations of university students (one of Local Students, LS, and another of Exchange Students, ES) were surveyed to analyze and compare students' perceptions of EP and to explore their vulnerability to EP. Based on student-based surveys and/or EP literature (e.g., Morris & Genovese, 2018; Kousis et al., 2020; Mamica et al., 2021; Nazarahari et al., 2021), an online survey in English and another equivalent in Spanish were created (considered a single survey). This survey was opened for responses between March and June of 2022 and disseminated across several digital platforms of the student communities (local and exchange) in the three cities, such as social media, international student networks, and by sharing from teachers. For the three cities, we received a total number of 299 responses to the survey, of which 295 were considered valid for analyzing the results. The survey had forty-four questions and eleven sections, and its questions were designed to characterize each population of students and to describe their energy consumption habits, energy related equipment, perception of EP, and their lived experience in maintaining comfortable internal temperatures.

In the second study, a similar online survey (with thirty-two questions and only a few writing changes) with two versions (in English and in Portuguese, considered a single survey) was opened for responses between September 2022 and April 2023. The analysis of the 911 responses to this survey is in progress, 600 of which came from the region of the metropolitan area of Lisbon, and the rest of the responses coming from 23 of the 25 Portuguese regions.

According to the results of the first investigation, comfort levels seem to vary according to location, type of students and season, but there seems to be an interaction between these three factors. In addition, most students didn't identify themselves as living in EP, but several populations perceived discomfort in both winter and summer, showing their vulnerability to EP.

The majority of students surveyed from all populations did not consider themselves to be in EP, but regarding the level of awareness of EP, both ES and LS of Lisbon were the only populations with a majority of "Concerned" or "Really concerned" students about the problem. Moreover, the students from Lisbon described more Discomfort than those from the other study sites, and Lisbon was the only city with the majority of both ES and LS, noting that their poor housing conditions affected them.

In relation to the level of comfort perceptions according to the type of student (ES or LS) in each season, the results show a situation for each location: in Padua, this factor does not seem to have been relevant (both ES and LS perceived the same level of comfort in each season); in Lisbon, it seems to have affected the summer-related responses (in summer, most ES felt comfortable, while LS felt uncomfortable); in the case of Montevideo, it appears to have affected the winter responses (in winter, most ES felt uncomfortable, while LS felt comfortable).

The EP situation seems to be more problematic in Montevideo and Lisbon than in Padua during winter, a pattern that can be explained by the fact that most of ES in Montevideo and Lisbon had poor housing conditions, which affected them (may explain their Discomfort in winter) and that in Padua most students did not report the presence of problems in their accommodation (may explain their Comfort during winter). Besides that, compared to the other cities, in Padua, more students were living in a dormitory of a residence, and there was a generally higher percentage of satisfaction with the accommodation.

However, the more problematic EP situation that seems to exist in Montevideo and Lisbon, does not seem to have been perceived by the LS in the same way. In fact, while most LS in Montevideo felt comfortable in winter and summer, most LS in Lisbon did not feel comfortable in both seasons. This discomfort from Lisbon LS may be explained by the fact that, contrary to Montevideo LS, most of the LS reduced energy use because they were concerned about the energy bills (in winter) and did not have cooling devices (in summer). Contrary to what would be expected, students from Lisbon were more selective when house hunting (possibly, because they are more aware of the problem) and the house conditions of Montevideo had more issues than the ones of Lisbon (besides, most of Montevideo LS had considered their housing conditions not poor). These differences may be due to economic and/or cultural aspects of the two countries.

The solutions and policies proposed, in general, by 30% of all the students, could be used by the citizens and political agents of the studied cities, particularly to decrease the EP of Montevideo and Lisbon during winter. Giving a few examples, providing "subsidies to finance 100% renovation of energy-poor and rented housing", and improving the energy efficiency of buildings; which is already being done by the Italian and Portuguese Governments with the Superbonus 110% (Italian Government, 2022), in Italy, and the “Efficiency Voucher” and “More Sustainable Buildings” funding schemes in Portugal (Fundo Ambiental, 2022).

Some of the proposed solutions and policies are already encompassed in the draft version of the Portuguese National Strategy to Combat Energy Poverty (ENLPCPE). To reduce EP and promote decarbonization, the ENLPCPE sets four main objectives: improved energy performance of households, access to more energy services, reduced energy costs, and increased energy literacy (Portuguese Republic, 2023).

Although university students are often not directly targeted by policymakers (Morris & Genovese, 2018), the status of this group may be addressed by default through other policies without acknowledging the specifics of this group's vulnerability to EP. As an example, university students may live in housing where quality in relation to energy performance is covered by building standards, housing policies, and building specifications determined by the university.

As next steps, it is considered important to extend the analysis to the scale of each country under study, as it is being done for Portugal, by comparing the situation among regions within each country and between types of students (local or displaced), in order to capture the current reality of EP among higher education students living in these countries.

REFERENCES

European Commission. (2022). Energy Poverty. European Commission. Available online: https://energy.ec.europa.eu/topics/markets-and-consumers/energy-consumer-rights/energypoverty_en (accessed on 5 March 2022).

Fundo Ambiental. (2022). Programa Vale Eficiencia. Ministerio do Ambiente e Acao Climatica. Available at: https://www.fundoambiental.pt/apoios-prr/c13-eficiencia-energetica-emedificios/02c13-i01-programa-vale-eficiencia.aspx (accessed on 15 November 2022).

Healy, J. (2003). Fuel poverty and policy in Ireland and the European Union vol. 12 of studies In Public Policy. 1st ed. Dublin: The Policy Institute. Italian Government. (2022). Superbonus 110%. Available at: https://www.governo.it/it/superbonus (accessed on 15 November 2022).

Kousis, I., Laskari, M., Ntouros, V., Assimakopoulos, M. N., & Romanowicz, J. (2020). An analysis of the determining factors of fuel poverty among students living in the private-rented sector in Europe and its impact on their well-being. Energy Sources, Part B: Economics, Planning and Policy, 15(2), 113–135. https://doi.org/10.1080/15567249.2020.1773579

Mamica, Ł.; Głowacki, J.; Makieła, K. (2021). Determinants of the Energy Poverty of Polish Students during the COVID-19 Pandemic. Energies 2021, 14, 3233. https://doi.org/10.3390/en14113233
Morris, J., & Genovese, A. (2018). An empirical investigation into students' experience of fuel poverty. Energy Policy, 120(February), 228–237. https://doi.org/10.1016/j.enpol.2018.05.032
Nazarahari, A., Ghotbi, N., & Tokimatsu, K. (2021). Energy poverty among college students in japan in a survey of students' knowledge, attitude and practices towards energy use. Sustainability (Switzerland), 13(15). https://doi.org/10.3390/su13158484
Portuguese Republic (2023). Long Term National Strategy for Energy Poverty Mitigation 2021-2050. Document for Public Consultancy. Ministry of Environment and Climate Action. Portuguese Republic. January 2023. Available at: https://www.consultalex.gov.pt/Portal_Consultas_Publicas_UI/DetalheConsultaPublica.aspx?Consulta_Id=280 (accessed on 22 February 2023).

PORTUGUESE DWELLINGS ACCESS TO MOBILITY IN AN EVERGROWING ENERGY VULNERABLE REALITY

João Bodião[1], João Pedro Gouveia[2]

1 NOVA School of Science and Technology, NOVA University Lisbon, Campus de Caparica, 2829-516, Caparica, Portugal, j.bodiao@campus.fct.unl.pt

2 CENSE – Center for Environmental and Sustainability Research & CHANGE - Global Change and Sustainability Institute, NOVA School of Science and Technology, NOVA University Lisbon, Campus de Caparica, 2829-516, Caparica, Portugal

Keywords: Energy Poverty; Transport Poverty; Double Energy Vulnerability; Portugal.

1 INTRODUCTION

We live in an ever-so-growing demanding world, both economically and energy speaking, where modern-day societies, wherever they live, are struggling to cope with both energy demand and energy costs. Not helping, a global pandemic, rapidly followed by unexpected geopolitical events occurring in East Europe, sparked a global energy crisis, having far-reaching implications for entire economies, in the likes of living costs with energy prices being at the forefront of it (World Bank, 2022). In this context, households were led to painful sharp pressures on their energy bills and forcefully pushed into poverty realities (IEA, 2022) (World Bank, 2022).

In this regard, international studies are emerging, intending to explore and expand the horizons of Energy Poverty (EP) as a vulnerability while looking deeper into transport and mobility, acknowledging it as 'Transport Poverty (TP)', adding to the more established and well-known *enforced incapacity to obtain and use defined necessary amounts of domestic energy services, such as heat, hot water, and lighting*, also known as EP (e.g., Mattioli et al., 2017; Robinson & Mattioli, 2020; Simcock et al., 2021). For reference, TP is the "*enforced lack of mobility services necessary for participation in society, resulting from inaccessibility, and or unaffordability, and or unavailability of transport*" as per (Lowens et al., 2021). At European level, indicators like "Inability to keep home adequately warm" or "Arrears on utility bills", available in the European Poverty Advisory Hub (EPAH) (see EPAH, 2023) online interactive dashboard, are already used to quantify "*aspects of energy poverty levels across Europe using the most recent EU wide statistics*".

Within this matter, policies like the '*Warmer Homes Scheme'*, taking place in Ireland – which provides energy upgrades to homeowners below a certain income threshold (or granted by some sort of social welfare allowance), without any extra costs to homeowners –, or the '*Disconnection protection Catalonia*' programme in Catalunya – which protect the most vulnerable dwellings from getting cut of essential needs like electricity, gas and water supply –, are trying to tackle domestic EP.

In this context, past studies have extensively looked into household EP as well, like Karpinska *et. al.*, 2021; Mahoney *et. al.*, 2020; and Horta *et. al.*, 2019, in example. Karpinska *et. al.*, 2021, focused on accessing regional vulnerability to EP in Poland, using national databases for data extraction, assessing in the end that certain districts are more likely to attain EP policy actions. Mahoney *et. al., 2020*, targeted the potential of the United Kingdom for application of a common methodology for EP assessment. Their

results showed that, even though large amount of data were available, it was not possible to find common grounds to compare data between countries. Horta *et. al., 2019,* based on a quantitative analysis, were able to entirely characterize every Portuguese parish contributing to a better understanding of EP in Portugal, using an EP vulnerability index.
In that sense, this research has as its primary objective to explore this dimension of vulnerability in access to transport/mobility in Portugal, resorting to the identification and analysis of relevant indicators, comparing it with the already identified vulnerabilities related to the residential sector (e.g., in Gouveia et al. 2019; EPAH, 2023), enabling, above all, the beginning of a discussion and characterisation of the problem of mobility intertwined with other related household level energy vulnerabilities, with a view to the development of new, or ongoing political energy, housing, environmental and/or mobility synergies.

2 METHODOLOGY

2.1 Literature Review

A thorough assessment of the available literature was done to gain a thorough grasp of the state of the art in the field and to spot any gaps that the ongoing inquiry work may fill, as well as to obtain an overview of existing indicators for this matter, which is explained further down.
A selective search method was devised across multiple scientific databases, including Science Direct, Web of Science, Scopus, and Google Scholar, to find pertinent peer-reviewed publications such as articles, papers, and other sources. A timeframe from 2010 to 2023 was chosen. Moreover, studies and other references from respectable international organizations, like the International Energy Agency (IEA) and the World Bank (WB), were all included in the inclusion criteria.
As previously stated, only recently, TP studies are emerging related to EP aiming to better conceptualize this phenomenon. In Figure 1, TP is shown as related to EP, with both concepts combined to define Double Energy Vulnerability (DEV).
From the kick-off, basic keyword searches were conducted (*e.g.,* 'energy poverty'; 'transport poverty'; 'double energy vulnerability'). Nonetheless, to ensure that all pertinent material was found, Boolean operators were deemed necessary to ensure so, with refinements being done during the search process.

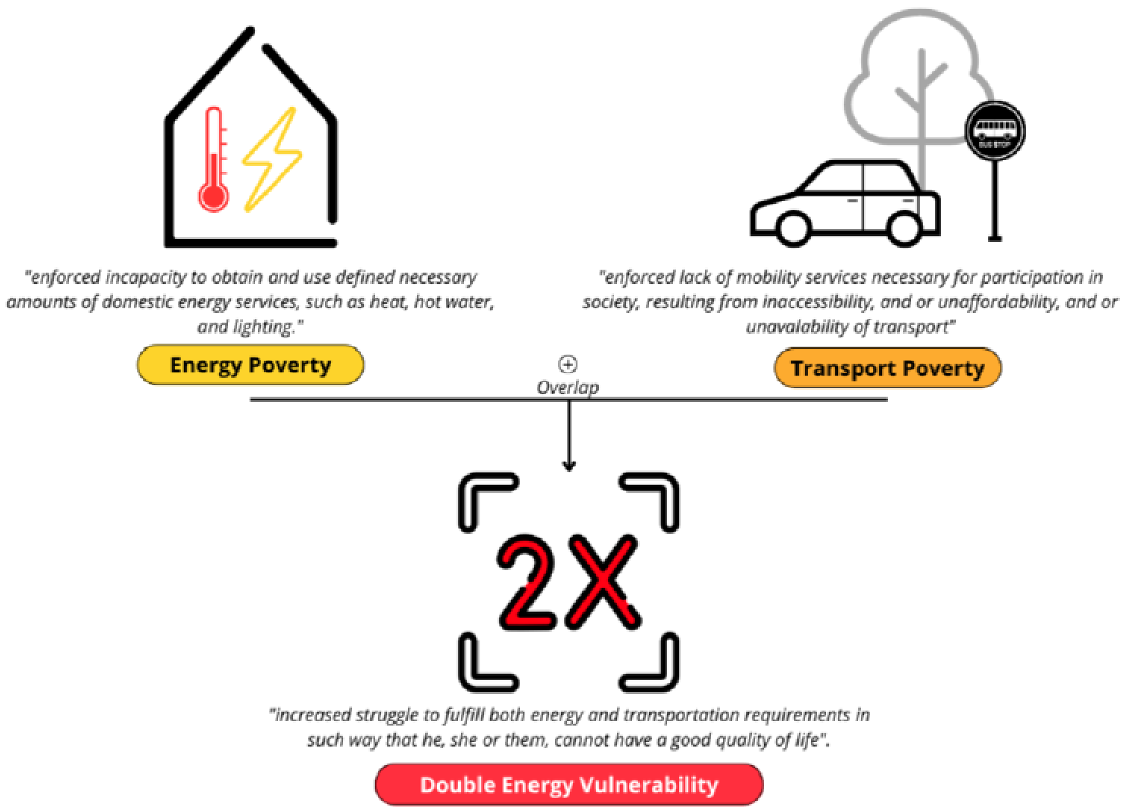


Figure 1 - Main factors comprising Double Energy Vulnerability. Adapted from (Lowens et.al.,2021).

2.2 Case study selection: Portugal

The selection of Portugal as a case study arises from two main reasons, albeit somewhat similar and interconnected. The lack of mention of transportation or mobility difficulties when echoing Portugal's residential lack of energy efficiency and thermal comfort (e.g., Palma et al., 2019) in its dwellings and population prompts the existence of a research gap. This discrepancy fails to exhibit said energy setback regarding social inclusiveness and households' capabilities to withstand possible trade-offs pertaining to energy-related vulnerabilities.

2.3 Selection of Pertinent Indicators for Vulnerability Analysis

Regarding the selection of relevant indicators for vulnerability analysis, a similar search procedure was put in place. Besides the aforementioned databases, other sources like Eurostat, the Organisation for Economic Co-operation and Development (OCDE), and the EPAH were also used for data extraction and to obtain an overview of the existing indicators around and within the field of transportation related to EP. Several dozens of indicators were retrieved. Due to data availability, only a fraction (around 5-8 indicators) of the indicators identified will be further applied in vulnerability assessments and evaluations.

3 RESULTS

The Portuguese EP reality is already well documented (Horta *et. al.*, 2019). Potential results from this analysis will allow for a comprehensive description of the Portuguese reality regarding TP, adding to the aforementioned EP studies and enabling a complete DEV mapping of the Portuguese territory. Whilst on this subject, this DEV mapping will also work as means to a better understanding on whether TP vulnerabilities and respectively major drivers are, or not, coincident with ones from household EP.
Furthermore, as previously mentioned, this vulnerability analysis will occur resorting to relevant indicators. Although not yet fully defined, it is already known that these indicators follow one of three different contours, such as: i) metrics that estimate travel time, and/or, ii) metrics for affordability of transportation for dwellings according to their household expenditures ceiling, and/or, iii) metrics of accessibility/availability to transportation as well as the conditions how these are provided.

4 CONCLUSIONS

Concluding this work, possible future paths can be taken regarding the results obtained from this assessment. Paths mentioned above can be 1) the development of new or ongoing political energy, environmental, and/or mobility synergies in cooperation with energy field *stakeholders*, or 2) a direct-to-consumer approach with elocution of helping measures to refrain households and individuals from suffering from DEV, or even, 3) other pertinent ways that show themselves clear and helpful actions to take part in the combat to these vulnerabilities.

REFERENCES

Citizens Information. (2023, Last Update March 15th, 2023). Free energy upgrades (Warmer Homes Scheme). *Housing Grants and schemes.* Retrieved April 27th, 2023 from https://www.citizensinformation.ie/en/housing/housing_grants_and_schemes/warmer_homes_scheme.html

Comunidad Autónoma de Cataluña. (2015, Last Update n.d). Ley 24/2015, de 29 de julio. Retrieved April 27th, 2023 from BOE-A-2015-9725 Ley 24/2015, de 29 de julio, de medidas urgentes para afrontar la emergencia en el ámbito de la vivienda y la pobreza energética.

European Commission. (2023). National Indicators. *Energy Poverty Advisory Hub*. Retrieved April 20th, from https://energy-poverty.ec.europa.eu/observing-energy-poverty/national-indicators_en

Gouveia, J.P., Palma, P. Simoes, S. (2019). Energy poverty vulnerability index: A multidimensional tool to identify hotspots for local action. Energy Reports 5, November 2019, pp. 187-201. https://doi.org/10.1016/j.egyr.2018.12.004

Horta, A., Gouveia, J. P., Schmidt, L., Sousa, J. C., Palma, P., & Simões, S. (2019). Energy poverty in Portugal: Combining vulnerability mapping with household interviews. Energy and Buildings, 203, 109423. https://doi.org/10.1016/j.enbuild.2019.109423

IEA. (2022). *World Energy Outlook 2022*. Paris: IEA Publications. Available at https://www.iea.org/reports/world-energy-outlook-2022

Karpinska, L., Śmiech, S., Gouveia, J. P., & Palma, P. (2021). Mapping regional vulnerability to energy poverty in Poland. *Sustainability (Switzerland)*, *13*(19). https://doi.org/10.3390/su131910694

Lowans, C., Furszyfer Del Rio, D., Sovacool, B. K., Rooney, D., & Foley, A. M. (2021). What is the state of the art in energy and transport poverty metrics? A critical and comprehensive review. *Energy Economics*, *101*, 105360. https://doi.org/10.1016/j.eneco.2021.105360

Mahoney, K., Gouveia, J. P., & Palma, P. (2020). (Dis)United Kingdom? Potential for a common approach to energy poverty assessment. *Energy Research and Social Science*, *70*. https://doi.org/10.1016/j.erss.2020.101671

Mattioli, G., Lucas, K., & Marsden, G. (2017). Transport poverty and fuel poverty in the UK: From analogy to comparison. *Transport Policy, 59, 93–105.* https://doi.org/10.1016/j.tranpol.2017.07.007

Palma, P., Gouveia, J.P., Simoes, S. G. (2019). Mapping the energy performance gap of dwelling stock at high-resolution scale: Implications for thermal comfort in Portuguese households. Energy and Buildings (190), pp. 246-261. https://doi.org/10.1016/j.enbuild.2019.03.002

Robinson, C., & Mattioli, G. (2020). Double energy vulnerability: Spatial intersections of domestic and transport energy poverty in England. *Energy Research & Social Science, 70, 101699.* https://doi.org/10.1016/j.erss.2020.101699

Simcock, N., Jenkins, K. E. H., Lacey-Barnacle, M., Martiskainen, M., Mattioli, G., & Hopkins, D. (2021). Identifying double energy vulnerability: A systematic and narrative review of groups at-risk of energy and transport poverty in the global north. Energy Research & Social Science, 82, 102351. https://doi.org/10.1016/j.erss.2021.102351

The World Bank. (2023, Last Update November 2022). Overview. *Understanding Poverty*. Retrieved April 1st 2023, from https://www.worldbank.org/en/topic/poverty/overview

ENERGY POVERTY ADVISORY HUB: SUPPORTING ENERGY POVERTY DIAGNOSIS THROUGH INDICATORS SELECTION

Salomé Bessa[1,2], João Pedro Gouveia[1,3], Pedro Palma[1,4], Katherine Mahoney[1,5], Miguel Sequeira[1,6]

[1]*CENSE – Center for Environmental and Sustainability Research & CHANGE – Global Change and Sustainability Institute, NOVA School of Science and Technology, NOVA University Lisbon, Campus de Caparica, 2829-516, Caparica, Portugal.*
[2]*ss.bessa@campus.fct.unl.pt,* [3]*jplg@fct.unl.pt,* [4]*p.palma@campus.fct.unl.pt,* [5]*k.mahoney@campus.fct.unl.pt* ,[6]*m.sequeira@campus.fct.unl.pt*

Keywords: Energy Poverty, Energy poverty diagnosis, Macro indicators

Introduction

Energy poverty is a pressing global issue that affects individuals and families who struggle to afford sufficient heating, cooling, and other energy needs. The European Commission (EC) has acknowledged this issue and has incorporated energy poverty into its current legislative and policy frameworks, pushing Member States to further go in-depth in addressing the problem. The EU Energy Poverty Advisory Hub (EPAH) (www.energypoverty.eu), the Covenant of Mayors for Climate and Energy in Europe (CoM, 2022), and the Joint Research Center (JRC) (Koukoufikis and Uihlein, 2022) have all proposed frameworks and created sets of indicators for analysing energy poverty to help with this endeavour.
To effectively identify energy poverty in member countries, trustworthy indicators that capture its multiple dimensions are required for local governments support. In response to this problem, the EPAH is growing as a global initiative that promotes energy poverty eradication through research, capacity building, and policy development. The development of energy poverty indicators that can effectively quantify and monitor the extent and severity of energy poverty in various contexts is one of the EPAH's key areas of work.
This study looks into the EC's acknowledgement of energy poverty, the importance of exact diagnosis, and the steps taken by several initiatives, notably EPAH, to address this issue through reliable indicators, research, capacity building, and policy development.

Methodology

In response to Directive (EU) 2019/944 from the EC, Member States were required to evaluate the issue of energy poverty within their jurisdictions and estimate the number of individuals impacted by it as part of their National Energy and Climate Plans (NECPs). Additionally, they were asked to put forward potential measures and policies aimed at alleviating energy poverty if it was identified as a significant social burden. EPAH has undertaken extensive research and knowledge-gathering efforts pertaining to energy poverty at the subnational and local levels.
An extensive collection of more than 250 successful instances of efforts to alleviate energy poverty from various parts of the world has been carefully curated and presented in the online platform of the EPAH ATLAS. Additionally, reports on inspirational selected cases have been published (European Commission, 2021), and research publications on local assessment and indicators of energy poverty have been evaluated (Palma and Gouveia, 2022). The review, insights, and updates of indicators conducted by the team are available in the updated online indicators' dashboard located in the national energy poverty indicators section of the EPAH website (Gouveia et al., 2022). These efforts are contributing towards the development of effective policy responses to energy poverty and promoting a brighter future for all.

Results

EPAH gathered over 250 inspiring cases of energy poverty during a research session in 2021 and further updated when new projects and initiatives are identified or submitted by the users. These cases have been put into the EPAH ATLAS online interactive database, which allows visitors to find local and international projects and actions that address energy poverty around the world (European Commission, 2021). Visitors can browse the various projects and get a list of all cases available on the site by using the interactive map. Each case includes thorough information, and there is a number of quick and advanced filters accessible to make navigating through the cases simple and effective.
EPAH has also focused on macro indicators and how they can assist Member-States and other agency levels in developing national strategies and policies, better understanding the problem, and laying the groundwork for the planning and implementation of energy poverty mitigation measures (Palma and Gouveia, 2022). EPAH team updated and amended a set of 21 indicators for analysing energy poverty based on prior work by the EU Energy Poverty Observatory (EPOV) (Gouveia et al., 2022).
A complete overview of all the indicators available with important information about the sources, technical details, and additional insights into usability, limitations, and advantages is presented. These indicators were based mainly on Eurostat datasets and national Household Budget Surveys data, aiming to measure energy poverty in its multidimensionality across different national contexts. The EPAH team's work on indicator assessment, insights, and updates is also visible in the redesigned online indicators dashboard depicted in the Observatory's national energy poverty indicators portion of the EPAH website.
Overall, our EPAH's work emphasizes the problem of energy poverty and the necessity for continuous efforts to mitigate its effects. It is highlighted the necessity of policies that promote cheap energy access, energy efficiency, and economic help for individuals who are struggling to pay their utility bills.

Conclusion

Through its study and production of the EPAH ATLAS, which comprises inspiring cases of tackling energy poverty, we have amassed a wealth of knowledge and expertise. In addition, the EPAH team refined and updated a set of indicators to aid in the analysis of energy poverty at the national level. The findings highlight the importance of having an up-to-date, consistent, and complete set of national-level indicators to inform the government and identify effective solutions to this problem. The EPAH's work on diagnosing energy poverty has substantial implications for solving this serious issue at many spatial dimensions.

REFERENCES

CoM (2022) Reporting Guidelines on Energy Poverty, Covenant of Mayors. Available at: Covenant-reporting-guidelines-energy poverty-final.pdf (europa.eu)

EPAH. (2021). *Tackling energy poverty through local actions – Inspiring cases from across Europe. EU* Energy Poverty Advisory Hub. DG. Energy. European Commission Available at: https://energy-poverty.ec.europa.eu/discover/publications/publications/epah-report-tackling-energy-poverty-through-local-actions-inspiring-cases-across-europe_en

Gouveia, J.P., Palma, P. Bessa, S., Mahoney, K., Sequeira, M. (2022). *Energy Poverty National Indicators: Insights for a more effective measuring.* Energy Poverty Advisory Hub. DG. Energy. European Commission. Available at: https://energy-poverty.ec.europa.eu/discover/publications/publications/energy-poverty-national-indicators-insights-more-effective-measuring_en

Koukoufikis, G. and Uihlein, A. (2022), *Energy poverty, transport poverty and living conditions - An analysis of EU data and socioeconomic indicators*, EUR 31000 EN, Publications Office of the European Union, , ISBN 978-92-76-48396-0, doi:10.2760/198712, JRC128084.

Palma, P., Gouveia, J.P. c(2022). *Bringing Energy Poverty Research into local practice - Exploring Subnational Scale Analysis.* Energy Poverty Advisory Hub. DG. Energy. European Commission Available at: https://energy-poverty.ec.europa.eu/discover/publications/publications/bringing-energy-poverty-research-local-practice-exploring-subnational-scale-analyses_en

Partners