CIEEMAT`22

CIEEMAT 2022
VII Ibero-American Congress on Entrepreneurship, Energy, Environment and Technology

Book of Abstracts

6-8 July 2022
Bragança, Portugal

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CIEEMAT 2022 - VII Ibero-American Congress on Entrepreneurship, Energy, Environment and Technology
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ABOUT THE EVENT

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

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

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

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

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Building of Smart Plugs to Energy Efficiency in the Residence Load Management

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Abstract

It is known that electrical energy consumption is higher during the day than at night, which makes the electrical energy companies adopt some different tariffs during the peak time and of the peak. The peak time is usually the end of the afternoon when occurring more consumption and the energy gets more expensive. This method is an option adopted by ANEEL, a Brazilian agency of electrical energy, to consumers that will not spend so much energy during the peak time called "white tariff" in which the consumers pay tariffs out of the peak time cheaper than the conditional one that has the same price for all day [1].

In Portugal, there is something similar, but it is divided into three categories: simple tariff, which is the same price all day; bi-hourly tariff, which has empty time, that is cheaper than out of empty time, which is more expensive; the last one is the tri-hourly tariff which has an increase of one more time range with an intermediate price compared to the empty time and peak time [2].

In the case of photovoltaic systems, energy generation is higher during the day. Still, the consumption, thinking about the peak time, usually is low and, when it is night, is the opposite. One of the most significant issues with solar energy is the fact that it is unstable [3]. Alternatively, if it has a surplus, one way to allocate this energy is by storing it in batteries, which can be expensive and limited [4], or by sending it through transmission lines, which, in some cases, cannot be compensated [5]. It is necessary thinking an intelligent system that could redirect this surplus energy produced during the day to a load that needs to work during the day like a refrigerator, for example, to reduce the employment cost of a renewable source.

With a view to reducing energy consumption, the present work aims to develop smart plug modules that can self-manage power in residence, rerouting the surplus energy coming from renewable sources, and switching to conventional ones when it is over. This plug also can be able to choose the most efficient way in which the tariff is cheaper during the day. Using this surplus energy coming from photovoltaic panels, it could be eliminated or reduced the necessity of battery usage. In the end, the main objective is to develop an intelligent electrical management system that controls the power of loads, thereby optimizing energy efficiency.

Currently, smart plugs can be controlled remotely only through ON-OFF activation, but cannot automatically disconnect a load, for example [6], and do not have a sophisticated supervisory system that allows the user to determine the priority of each load. Some solutions can be founded using communication protocols like Zigbee in [7] controlling the activations of some loads with the help of some sensors. Works like [8] use WebApps that can show the bills.

To develop the smart plug of the present work, it will be using some fundamental electronics components like TRIAC as a switch and optocoupler to isolate the command circuit to the power circuit like shown in (4) of Figure 1. To control the power of the load through the current control it will be used the microcontroller of Arduino shown in (5) that is joined in the same Printed Circuit Board (PCB). The microcontroller will group all the components getting the data through the sensibility of an optocoupler, capable to detect each semicircle and send the signal to activate another one connected to TRIAC by the

alpha angle setting by the user in the code. A plug could be connected physically to a Node MCU ESP32 (6) that send information through the Wi-Fi connection to the supervisory center (7).

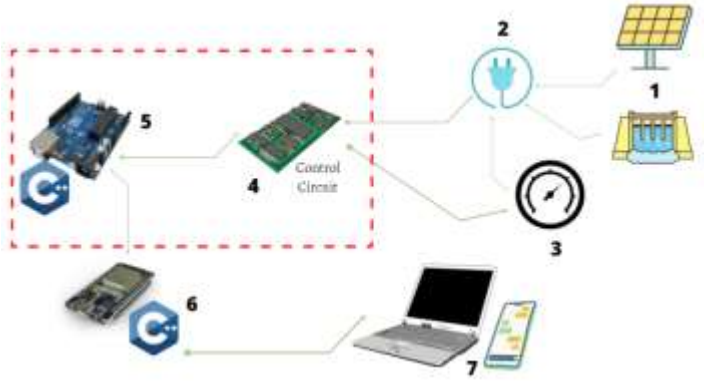

Figure 1 - Schematic of the smart plug operation.

The next step is developing a robust supervisory and control system that could be able to deal with all the plugs making the system take decisions automatically using the apparatus of Internet of Things (IoT). The project could be continued by increasing the machine-learning system to get more intelligence, such as weather conditions and the consumer lifestyle.

Keywords: Smart Plugs, Energy Efficiency, Renewable Sources.

References

[1] Governo do Brasil - Agência Nacional de Energia Elétrica, "Tarifa Branca," ANEEL, 2022. Available in <https://www.gov.br/aneel/pt-br/assuntos/tarifas/tarifa-branca>. Accessed in June 13th, 2022.

[2] Tarifas e Ciclos de Horários, Poupa Energia, 2022. Available in <https://poupaenergia.pt/tarifas-e-ciclos-horarios/>. Accessed in June 24th, 2022.

[3] Y. Hou, R. Vidu and P. Stroeve, "Solar Energy Storage Methods," *Ind. Eng. Chem. Res.*, no. 50, pp. 8954-8964, 2011, doi: 10.1021/ie2003413.

[4] F. Mohamad, J. Teh and C.-M. Lai, "Optimum allocation of battery energy storage systems for power grid enhanced with solar energy," *Energy 120105*, no. 223, pp. 1-12, Jun. 2021, doi: 10.1016/j.energy.2021.120105.

[5] Francisco Rodrigues, "Vender excedentes de painéis solares compensa? Saiba que passos dar ," Doutor Finanças, 2022. Available in <https://www.doutorfinancas.pt/financas-pessoais/vender-excedente-de-paineis-solares-compensa-saiba-que-passos-dar/>. Accessed in June 24th, 2022.

[6] K. L. Tsai, F. Y. Leu and I. You, "Residence Energy Control System Based on Wireless Smart Socket and IoT," *IEEE Acess*, vol. 4, no. 10, pp. 2885-2894, Jun. 2016, doi: 10.1109/ACCESS.2016.2574199.

[7] E. Al-Hassan, H. Shareef, M. M. Islam, A. Wahyudie, and A. A. Abdrabou, "Improved smart power socket for monitoring and controlling electrical home appliances," *IEEE Acess*, vol. 6, pp. 49292–49305, Sep. 2018. doi: 10.1109/ACCESS.2018.2868788.

[8] M. Rokonuzzaman, M. K. Mishu, M. R. Islam, M. I. Hossain, M. Shakeri, and N.Amin, "Design and implementation of an iot-enabled smart plug socket for home energy management," *IEEE 2021 The 5th International Conference on Smart Grid and Smart Cities (ICSGSC)*, IEEE Computer Society, 2021, pp. 50–54, isbn: 978-0-7381-3315-7. doi: 10.1109/ICSGSC52434.2021.9490420.

Smart System for Monitoring and Controlling Energy Consumption and Ambient Conditions

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Abstract

In the current energy context, alternatives are sought that provide a more conscious use of energy and the development of technology aimed at efficiently meeting the needs of energy consumers and the utility company. In this scenario, smart systems for monitoring and controlling the energy consumption of residential loads stand out. In [1], the authors worked on a system from which the user could monitor their energy consumption in real time. Through a website, the consumer accessed their information using visualizations in graphics, for example. Consumption data was obtained by a smart plug. Furthermore, the option to remotely turn devices on and off has been included in the system so that the user has the ease of controlling their devices.

In addition, data beyond power consumption can be included in these systems for user viewing, such as environmental conditions. In [2], Enrique Nodar Carro used Internet of Things (IoT) technologies to monitor data on temperature, humidity, brightness, presence, opening and closing of doors and windows, concentration of volatile compounds and CO2 in the air and electricity consumption. For data storage, the InfluxDB database was used and Grafana was chosen as the information visualization platform.

Thus, the objective of this work is to present the development of a system for monitoring and controlling energy consumption by residential loads connected to smart plugs, so that the user can visualize their consumption pattern, given the available energy, regardless of the source. In addition, environmental conditions such as temperature and humidity will also be analyzed by the consumer. In this way, the user will be able to make decisions regarding the energy use by their devices, based on consumption information, environmental conditions and, depending on their context, the energy available for consumption. It is worth mentioning that the control of domestic appliances will not only take place when they are turned on or off, but also through the control of the energy consumed by the devices. Within the scope of decision-making, the consumer can define a degree of priorities in the operation of their devices. Still in this scenario, the implementation of a decision-making system does not depend only on the choices of users. It is intended to implement machine learning in the decision system, based on the energy consumption pattern, allowing its use with greater awareness and effectiveness. Figure 1 presents the tools and solutions involved in the development of the monitoring and control system.

It is observed that the sensor data is captured by ESP32, a microcontroller with WiFi communication capability, through which there is a connection with an MQTT (Message QueuingTelemetry Transport Protocol) broker. This protocol will be used to connect to Node-RED, a tool used in IoT for systems integration [3]. Node-RED is also characterized as a control platform and,through this tool, data is sent to the InfluxDB database, from which it can be accessed by Grafana for user viewing. It can control the operation of loads and set priorities for its operation based onits consumption behavior. This decision making can also be done through tools such as machine learning.

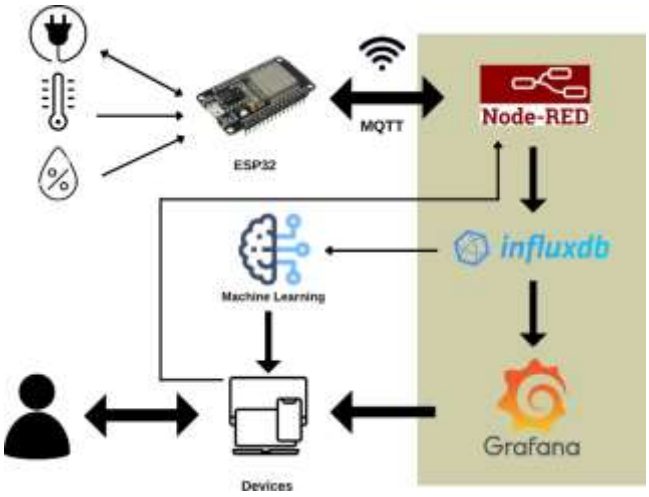

Figure 1 - Monitoring and control system of energy consumption by residential loads.

To simply exemplify the possibility of monitoring electrical appliances and environmental conditions, tests were started that included the measurement of voltage and electrical current generated by a photovoltaic module of nominal voltage 3.3 V, sending these data to InfluxDB, using the MQTT broker and Node-RED, and viewing this information in Grafana. Together, the DHT11 sensor was used to measure the temperature and humidity of the environment in order to send these data to the database and make them available for later viewing. These are tests thataim to attest to how broad, effective and evolved monitoring systems can be.

In this context, although there are already systems with similar functions, it is worth noting that the proposed system is open to new functionalities, such as the management and optimization of energy produced for self-consumption. In addition, the need for the system to communicate with others from different sources can be highlighted. Thus, in future works, the insertion of interoperability protocols to expand communication with the proposed system will be analyzed. However, initially, the hardware and algorithm presented will be validated. In this way, the evolution of data monitoring and systems control technologies within the energy sector confirms the undeniable need to understand generation and consumption patterns and behaviors and establish measures that can value energy efficiency and more conscious use of energy.

Keywords: Monitoring and Control, Energy Consumption, Temperature and Humidity, Priority of loads.

References

[1] A. Chaudhari, B. Rodrigues and S. More, "Automated IOT based system for home automation and prediction of electricity usage and comparative analysis of various electricity providers: SmartPlug," 2016 2nd International Conference on Contemporary Computing and Informatics (IC3I), 2016, pp. 390-392, doi: 10.1109/IC3I.2016.7917995.

[2] E. Nodar Carro, *Análise de consumo enerxético mediante tecnoloxías iot*, http://hdl.handle.net/10198/22817, 2020.

[3] P. Macheso, T. D. Manda, S. Chisale, N. Dzupire, J. Mlatho and D. Mukanyiligira, "Design of ESP8266 Smart Home Using MQTT and Node-RED," 2021 International Conference on Artificial Intelligence and Smart Systems (ICAIS), 2021, pp. 502-505, doi: 10.1109/ICAIS50930.2021.9396027.

Smart Buildings – A Case Study in Braganza

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Abstract

The advance in the dissemination of microcontrolled processes allowed an expansion in process control, making it possible to supervise and control equipment. But it was only in the 80s, with the need to improve common social spaces, that the three fundamental pillars of the intelligent building system emerged, namely automation, telecommunication, and computing systems. The emergence of the term "intelligent" applied to infrastructure ended up raising great expectations that were frustrated by the unfamiliarity with the use of new technologies [1].

In the research conducted by Wigginton and Harris [6], more than 30 definitions were found for the word "intelligent" when related to buildings. In this way, two institutions were created with the intention of centralizing and promoting the discussion of issues related to intelligent buildings. In the United States, the Intelligent Building Institute was created in 1986, which defined an intelligent building as a building that makes its environment productive and profitable through the optimization and interrelationship between four systems (structure, systems, services, and management). In contrast, the UK-based European Intelligent Building Group interpreted an intelligent building as a place that maximizes the effectiveness of the occupants of the building while enabling the management of resources by minimizing lifetime equipment and installation costs. Among these and other definitions found in [6], it can be concluded that an intelligent building will present an integration between the monitored systems to centralize the control of the building.

The system developed in this project integrates three main systems: electricity consumption, water consumption, and waste disposal. The project, developed entirely within the Apolo building in Braganza, Portugal, aims to create a database with information from these systems. This consumption data will then be analyzed by a machine learning algorithm to correlate a resident's behavior with certain consumption patterns. This would enable projections of future consumption and possibly indicate behavioral changes to improve a resident's consumption profile.

For the first system, the IoTaWatt [2] equipment was used, which counts on Hall effect clamps to make the electricity consumption measurement without the need to interrupt the system. For the flow measurement system, the YF-B2 [5] sensor was used, which had a water flow reading of 1-25L/min. Finally, for the waste disposal system, a load cell [4] was used in conjunction with a 3D printed base prototype. To perform better comparisons and data analysis, temperature and humidity sensors (DHT11 [3]) were also inserted into the system. The choice for these particular sensors was motivated by the desire to keep a low cost design that would still meet the requirements for the analysis.

The data collected by the YF-B2, load cell, and DHT11 sensors are transmitted via Wi-Fi through the ESP32 microcontroller to a database in InfluxDB. The IoTaWatt has an internal microcontroller and sends via Wi-Fi directly to the same database. Figure 1 shows a simplified diagram of the system architecture. For the first tests with IoTaWatt, two sensors were installed to measure the apartment's overall consumption and the air conditioning's consumption. In addition, the Grafana application is being used for better visualization of the data. Since the building is still in the final stages of construction and there are no residents, it was possible to perform several tests and adjustments to the entire proposed system.

The data collected, despite not being from real consumption, makes it possible to validate the system.

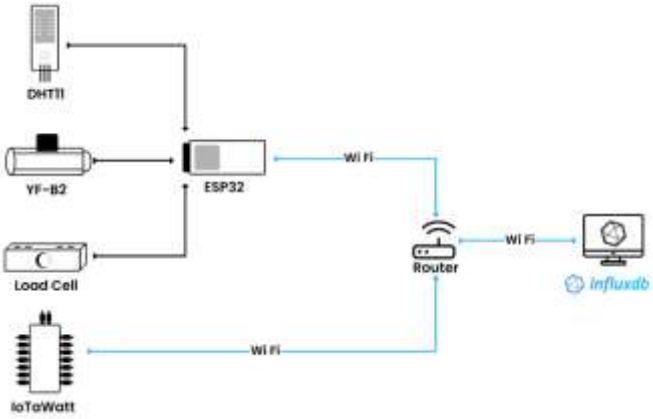

Figure 1 - Simplified System Architecture

We are currently designing a PCB that, beyond the base system developed for this project, will simplify the addition of other sensors to monitor different variables in the apartment, e.g., light intensity or air quality. Thus, the PCB will not be limited to only the systems already used for this project, allowing future expansion of the system. After the physical validation of the system, machine learning with linear regression will be applied to analyze the data and its relationships. For example, the ML algorithm will detect the relationship between increased water or energy consumption and an increase in temperature. This analysis will enable the creation of a consumption profile for each resident.

As a future work and continuation of this project, it can be mentioned the creation of a specific application for the resident, transmitting the collected data and ecological alternatives to their consumption. Through this interactive visualization with the data, which will only be collected with the resident's consent, it will be possible to analyze whether there was a change in their behavior. This application can be done via smartphone or even through the interactive screen already present in the apartment.

Keywords: Internet of Things, Smart Buildings, WSN.

References

[1] de Pádua, I.P.: "Caracterização de Edifıcios Inteligentes - Um caso exemplo". M.S. thesis. Pontifícia Universidade Católica de Minas Gerais, MG, Brasil, 2006.

[2] IoTaWatt, "The best kept energy monitoring secret.". https://iotawatt.com/ (accessed Mar. 21, 2022)

[3] Mouser Electronics, May, 2022, "DHT11 Humidity and Temperature Sensor". Available: https://www.mouser.com/datasheet/2/758/DHT11-Technical-Data-Sheet-Translated-Version-1143054.pdf

[4] RobotShopshop, May, 2022, "Micro Load Cell (0-5kg)". Available: https://www.robotshop.com/media/files/PDF/datasheet-3133.pdf

[5] SEEED, May, 2022, "Water Flow Sensor YF-B2". Available: https://media.digikey.com/pdf/Data%20Sheets/Seeed%20Technology/114991172_Web.pdf

[6] Wigginton, M., Harris, J.: *Intelligent skins. Routledge* Woburn, MA, EUA: Routledge, 2013.

Simulated Microcontrolled Photovoltaic Irrigation System for Family Farming

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Abstract

Population growth has several consequences, among them, the increase in energy demand. Knowing this, there is a need to explore new forms of energy production, which are cleaner and more economical, and as a way of mitigating this problem, new forms of electrical energy production were introduced to the detriment of the use of fossil fuels: renewable energies [1].

Therefore, alternatives were analyzed in Brazil for the production of renewable energy based on the Brazilian relief, available natural resources, applicability, among others, the main one being solar energy - considered the most viable due to the solar potential in the country. With this, we have countless possibilities to install solar energy generation systems, in which it is essential for the reduction of environmental impacts that can be verified with the use of this form of alternative energy production [1].

It is also relevant to emphasize that the generation of solar energy can be photovoltaic, that is, using photons originating from solar radiation that reach the conductive or semiconductor material to obtain electric current. In view of this, there is a demand for the deployment of solar panels with diverse applications such as in buildings, transportation, portable devices, solar- powered satellites and pumping systems.

Therefore, for the application and use of solar energy, the system created will produce enough energy potential to meet the demands of a reduced cultivation and production system, such as a systematization of family agriculture, in which the full billing results from the production itself and from the family self-consumption, focusing on preserving the functioning similar to the medieval method, that is, the peasant production procedure [2].

So, the criteria for recognition of the public responsible for following the guidelines established by the National Policy for Family Agriculture include, the use of the majority of the employees to come from the same family, perseveringly following sustainability, decentralization and acting in the creation and development of the policy that governs them [3].

One of the adversities faced by family farmers is the negligence in obtaining an adequate system for the aptitude of investment, in relation to the size of their rural possessions and in each different necessary manpower, employed [4], therefore, starting to use an automated system specifically designed to meet the needs of the establishment is of great importance in several areas.

To carry out this project, the Proteus system was used to carry out a practical simulation of the project, in order to obtain results similar to those expected effectively. In the Proteus software, electronic systems can be developed and simulated to obtain results before applying the system to practice. In addition, to perform the simulations in Proteus, the programming was made in ESP32, a microcontroller that consists of the junction of hardware components and software resources, which through programming it is possible to perform various types of functions [5].

In addition, the ESP32 has the prospect of making use of a wireless connection, either via wifi or bluetooth. From this, basic programming in C/C++ languages was used, to be able to execute the simulated test, tests were carried out in the programming and, through these tests, correct operation was verified.

It is thus inferred that the microcontrolled system by ESP32, also making use of a complete systematization of photovoltaic energy and several other components, are capable of enabling an improvement in the form of production in a sustainable and modest way, being an efficient systemmodel of irrigation for family agriculture, of course, after all approval in tests carried out in the simulation of the Proteus software.

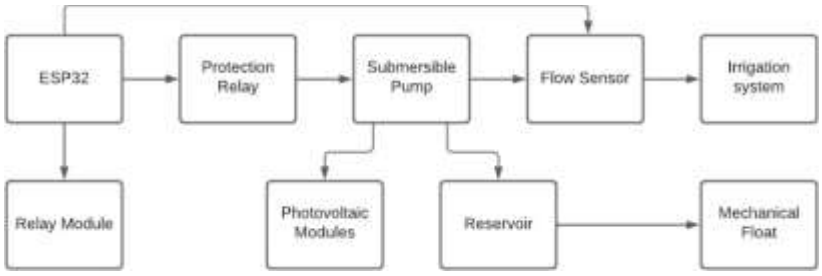

Figure 1- Simulation Block Diagram

Keywords: Solar energy, Microcontroller, Sustainability.

References

[1] J. Goldemberg and O. Lucon, “Energias renováveis: um futuro sustentável'', `` Revista USP, vol. 0, no. 72, p. 6, Feb. 2007, doi: 10.11606/issn.2316-9036.v0i72p6-15.

[2] A. S. dos Santos, “La organización de la unidad económica campesina: perspectivas repensadas”, RELACult, vol. 4, nº 3, fev. 2019.

[3] L. I. L. Silva and G. Cassel, Lei no 11.326,” www.planalto.gov.br, Jul. 24, 2006. http://www.planalto.gov.br/ccivil_03/_Ato2004-2006/2006/Lei/L11326.htm.

[4] M. S. Armando, Y. M. Bueno, E. R. S. Alves, and C. H. Cavalcante, “Agrofloresta para Agricultura Familiar Desenho da Agrofloresta,” Dec. 2002. Accessed: Jun. 09, 2022. [Online]. Available: https://www.infoteca.cnptia.embrapa.br/bitstream/doc/184803/1/ct016.pdf

[5] M. Babiuch, P. Foltýnek and P. Smutný, "Using the ESP32 Microcontroller for Data Processing," 2019 20th International Carpathian Control Conference (ICCC), 2019, pp. 1-6, doi: 10.1109/CarpathianCC.2019.8765944.

Microgrid Integration: An Opportunity that Need Challenges

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Abstract

Integration of Distributed Energy Resources (DERs) provides benefits and is required to raise new challenges to the conventional electricity market [1], including central management and control for several coordinated energy units to build a MicroGrid (MG) infrastructure that brings an efficient operation for the system [2]. However, DERs infiltration and incorporation rules are conflicting and will ultimately debilitate the improvement of the area in terms of efficient use of resources and technology [3]. The use of installed DERs and penetration into the energy market can provide opportunities. In fact, this integration will have a direct impact on the primary oil market, by reducing the dependence on electrification allowing the regulating of prime fuel market competition. An experience shown by developing countries like China or even India [4] have already used microgrid infrastructure, this had led to a reduction from conventional electrification by diverting this recovery to other industrial sectors and reducing the fuel demand [5]. Renewable Energy Sources (RES) are abundant in nature including sun and wind, despite their intermittent nature, this does not prevent them to contribute in solving the problem of global warming [6]. Several countries have an abundance of natural and renewable resources that can be successively incorporated to achieve a portion of the demand [7], as an example, Portugal currently has 5.4 GW of installed wind capacity and enough onshore wind to cover 24% of the country's electricity consumption, the third-highest in Europe after Denmark and Ireland. Portugal's ambitious National Energy and Climate Plan aims to increase the share of renewable energy in primary energy consumption from 31% in 2020 to 47% by 2030 [8], RES generating systems can be configured to support the existing utility network or as stand-alone in either urban or rural surroundings by exploring their conversion and aggregation as a microgrid system [9]. Many developing and third world countries lack electrification especially in the case of remote areas where transmission infrastructures need a large investment, in fact, African and South-Eastern countries, in particular, have the highest percentage of rural darkness [10], in the other hand, these countries stand out on a great renewable resource waiting to be exploited, as a concrete example, Algeria's photovoltaic potential is estimated at nearly 2.6 million TW.h per year, equivalent to 105 times the world's electricity consumption, Moreover, it has the highest onshore wind power potential in Africa, reaching 7,700 GW [11], considering that, the desirability of implementing MG at various scales is apparent from the richness of these countries in local RES, such as sun and wind. The integration of Microgrids can contribute to principal grid failure especially demand during peak periods when the demand in terms of energy is massive [12]. Virtual power a concept was introduced in late 1996 to support utilities in the United States by driving additional power from neighbors at the first sign of a demand deficiency [13], interconnected MGs can easily co- ordinate to serve the existing principal infrastructure, with advances in Utility communication, such coordination is feasible using reliable global Energy Management System (EMS) [14]. Despite their great benefits, several challenges have still to be overcome in the MG integrations, these can be divided into two main categories including technical challenges covering safety, stability, reliability, and protection are the key issues of microgrids due to reverse power flows of distributed generation units, local oscillations, transient modes of microgrid, severe frequency deviations in islanded mode operation, and economical and supply-demand uncertainties of a microgrid are all among the urgent concerns need to be addressed. On the

other side, Non-technical challenges: issues such as pricing, incentives, decision priority, risk responsibility, and insurance for new technologies adaptation and interconnection standards [15]. This work is an abstract for a review paper treating the trends in microgrid systems.

Keywords: Renewable Energy System, Distributed Generation, Microgrid, Energy Integration.

References

[1] do Prado, Josue Campos, Wei Qiao. "A vision of the next-generation retail electricity market in the context of distributed energy resources." 2018 IEEE Power Energy Society Innovative Smart Grid Technologies Conference (ISGT). IEEE, 2018.

[2] Elmouatamid Abdellatif, . "Review of control and energy management approaches in micro-grid systems." Energies 14.1 (2020): 168.

[3] Gazijahani, Farhad Samadi. "Optimal day ahead power scheduling of microgrids considering demand and generation uncertainties." 2017 Iranian Conference on Electrical Engineering (ICEE). IEEE, 2017.

[4] Sharma, Harpreet, Sachin Mishra. "Techno-economic analysis of solar grid-based virtual power plant in Indian power sector: A case study." International Transactions on Electrical Energy Systems 30.1 (2020).

[5] Khorasany Mohsen . "Transactive energy market for energy management in microgrids: The monash microgrid case study." Energies 13.8 (2020).

[6] Shearer christine . "The effect of natural gas supply on US renewable energy and CO2 emissions." Environmental Research Letters 9.9 (2014): 094008.

[7] Ayoub, Nasser, Naka Yuji. "Governmental intervention approaches to promote renewable energies—Special emphasis on Japanese feed-in tariff." Energy Policy 43 (2012): 191-201.

[8] Godinho, Miguel, Rui Castro. "Comparative performance of AI methods for wind power forecast in Portugal." Wind Energy 24.1 (2021): 39-53.

[9] Motjoadi Vinny, Pitshou N. Bokoro, Moses O. Onibonoje. "A review of microgridbased approach to rural electrification in South Africa: Architecture and policy framework." Energies 13.9 (2020): 2193

[10] Williams Nathaniel. "Enabling private sector investment in microgrid-based rural electrification in developing countries: A review." Renewable and Sustainable Energy Reviews 52 (2015): 1268-1281.

[11] Bouzid Zakaria, Nassera Ghellai. "Overview of solar potential, state of the art and future of photovoltaic installations in Algeria." International Journal of Renewable Energy Research (IJRER) 5.2 (2015): 427-434.

[12] Ouramdane Oussama. "Optimal Sizing and Energy Management of Microgrids with Vehicle-to-Grid Technology: A Critical Review and Future Trends." Energies 14.14 (2021): 4166.

[13] Panwar, Kaushik, Kothari. "Role of renewable energy sources in environmental protection: A review." Renewable and sustainable energy reviews 15.3 (2011): 1513- 1524.

[14] Aliabadi, Farshad Etedadi. "Coordination of smart home energy management systems in neighborhood areas: A systematic review." IEEE Access (2021).

[15] Nigim, Khaled A., and Wei-Jen Lee. "Micro grid integration opportunities and challenges." 2007 IEEE Power Engineering Society General Meeting. IEEE, 2007.

Wind Turbine Data Visualization Based on Principal Component Analysis

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Abstract

Wind energy is an essential clean and renewable energy resource available in nature. The wind turbine is responsible for transforming wind energy into electrical energy using the wind that moves the blades and turns the rotor, which transmits the rotation to the generator.

According to [1], wind energy is the fastest-growing renewable energy source, but the operation and maintenance of turbines account for about 25% to 35% of the generation costs.

The problems related to wind turbine maintenance are usually the failure of the electrical system and those resulting from extreme weather conditions. The failure of a component causes a reduction in productivity or even a shutdown of the turbine. For this reason, the most effective way to reduce maintenance costs is to monitor the status of generators and predict their malfunction before the system fails [2]. Thus, early fault diagnosis is critical in significantly reducing maintenance costs. Most works on fault detection in wind turbines use operational and event data sets, such as those provided by SCADA [3].

This work presents an initial exploratory analysis of a real wind turbine dataset extracted from SCADA, applying the Principal Component Analysis (PCA) technique to reduce the dimensionality of the data. PCA technique has the objective of explaining the variance and covariance structure of a random vector through the construction of linear combinations of the original variables. These combinations are called principal components and do not correlate amongst each other. In this technique, the variance of principal components is equal to the correspondent eigenvalue. The first principal component is the one with more considerable variance, and the others appear in variance decreasing order.

The database used is provided by the Energias de Portugal (EDP) company [4]. According to [5], EDP's data is a dataset available for wind resource analysis and wind turbine performance research. This work focuses on meteorological data that is composed of: wind speed and direction information, ambient temperature, pressure, humidity, precipitation, rain detection, and the anemometer.

In order to evaluate the joint variation behavior of these variables, a multivariate principal component analysis was performed based on the correlation matrix. The data was normalized to eliminate the discrepancy of the measurement units between the variables. The number of principal components was based on the graphic analysis criteria and according to the desired percentage of minimum information loss.

All the analyses use computational routines implemented in the software R version 4.1.1 [6]. Table 1 presents the first ten components generated by PCA with their respective percentage of explained and cumulative variance.

The first six components have an eigenvalue greater than 1.0 and explain approximately 85% of the data variance. We can effectively reduce the dimensionality from 28 to 6 while "losing" about 15% of the variance.

Table 1. Eigenvalues and Variance.

Components	Eigenvalues	% Variance	% Cumulative Variance
1	9,30	33,20	33,20
2	4,74	16,94	50,14
3	3,99	14,24	64,38
4	2,56	9,16	73,54
5	2,08	7,41	80,95
6	1,21	4,33	85,28
7	1,02	3,64	88,92
8	1,00	3,57	92,48
9	0,93	3,34	95,82
10	0,45	1,60	97,42

This information allows us to conclude that focusing on these 6 principal components can result in resource savings without significant information loss. In future work, other techniques to reduce dimensionality will be attempted, and some machine learning methods will be applied to fault detection in wind turbines.

Keywords: Wind Turbine, Pre-Processing, Principal Component Analysis.

References

[1] A. Blanco-M et al., "Impact of targe variable distribution type over the regression analysis in wind turbine data". I*n* International Conference and Workshop on Bioinspired Intelligence (IWOBI), 2017, pp. 1–7.

[2] S. Qin et al., "Ensemble Learning-Based Wind Turbine Fault Prediction Method with Adaptive Feature Selection," In Data Science - Third International Conference of Pioneering Computer Scientists, Engineers and Educators (ICPCSEE), September 2017, pp. 572-582

[3] A. Setco et al., "Machine learning methods for wind turbine condition monitoring: A review", Renewable Energy, vol. 133, 2019, pp. 620-635.

[4] EDP - Open Data, \url{https://opendata.edp.com/pages/homepage/}, Acessado em 15/08/21},

[5] D. Menezes et al., "Wind Farm and Resource Datasets: A Comprehensive Survey and Overview", Energies, vol. 13, 2020.

[6] R Core Team, "R: A Language and Environment for Statistical Computing}", R Foundation for Statistical Computing, 2014. Evaluate at: http://www.R-project.org/},

Brazilian PV Power Converter Substations

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Abstract

The construction of large-scale photovoltaic projects is characterized by the intense investment of capital in a short schedule of time and must match the technical developments and projections cost of the main components. [1]. The use of prefabricated solutions made in Brazil is very frequently, mainly because the tax, financing and exchange conditions. Those Made in Brazil Power Converter Substations (PCS) continues in a process of development at the Brazilian electrical segment, due to its various advantages of modularization, assembly and factory tests. Accelerating the installation and start-up at the field, where deadlines are short and the availability of qualified labour can be reduced [2], the solution can be applied even in High Voltage, like the application for the Distributor Network Operator (DNO) of the of Minas Gerais state in Brazil [3].

Undoubtedly the most iconic element of the photovoltaic unitary substation is the inverter, when the central inverter solution is applied, or the set of small ones in the string solution. However, other equipment makes up the PCS, such as the step-up transformer (TR) for medium voltage and the protection and control devices embedded in the medium voltage switchgear. This set of equipment, if housed in a metallic box, will be called E-house, or if executed in a version for external use and fixed under a metallic base, will be called skid [2]. Regardless of the constructive model adopted at the PCS, they need to be very compact to reduce the costs even at transport, demanding the use of compact Gas Insulated Switchgear (GIS), ready for external application.

Those large photovoltaic projects demand a very large field to install the photovoltaic modules like Pirapora PV plant with 300MW, taking 800 hectares, [4]. This large amount of area also impact with huge distances from the main substation, in high voltage, responsible to connect the Photovoltaic plant at the grid. Those distance can be bigger than 4700m and make technically and economically impossible to supply from the main substation an ancillary voltage at the skid.

An ancillary voltage can be also supplied by the central inverter or by one no break installed at the low voltage switchgear at the skid, if the skid is already connected to the grid and the power transformer is already connected too. The possibility of one fault at the skid, in the moment of the connection at the grid, is one concern of the Brazilian skid manufacturer, not familiar with the use of self-powered relay, like Europeans distributor network operators and wind farm assemble engineers.

This study analyzes one self-powered operation and compare the pickup condition in a real coordinate chart, proving the relay efficiency in self powered or external powered condition, mitigating the damage of one fault at the skid in the event of no ancillary voltage, due to a defect in the equipment responsible for providing it or due to human error. [5].

Keywords: Photovoltaic Power Generation, Protective Relays; Electric Inverters.

References

[1] Guarnieri, M. V. Usinas solares fotovoltaicas com seguimento em um eixo no Brasil: aspectos da construção, custos e expectativa de desempenho, 2017, Dissertação (mestrado em Engenharia Civil) Universidade Federal de Santa Catarina, Florianópolis , 2017. https://repositorio.ufsc.br/handle/123456789/189002.

[2] Gesualdi, M. E. R. Eletrocentros e sistema integrado de automação. In. Seminário de Automação e TI Industrial, 19, Rio de Janeiro, 2015, Anais, Rio de Janeiro, ABM, 2015, p. 274-282. ID: 10.5151/2237-0234-26986

[3] Assis, S. D. C. et al. Subestação compacta integrada - SECI, um padrão estrategico de sucesso para expançãodos istema elétrico da CEMIG In: Seminário nacional de produção e transmissão de energia elétrica, 25, 2019. Belo Horizonte. Anais, Belo Horizonte, [s.n.], 2019, p. 1 - 9. http://www.bvr.com.br/snptee/xxvsnptee/public/GSE/4314.pdf.

[4] Preti, F. A. Plano de controle ambiental PCA - USINA SOLAR PIRAPORA 1, 2, 3, 4, 5, 6, 7, 8, 9 e 10. Anjo Azul consultoria ambiental. Votuporanga, 2016, p. 1 – 129.

[5] Shuguang, L.; Qiulan, K.; Wenssheng, S. Design of self-powered digital over-current protector. In: International Conference on Electrical and Control Engineering, 2011, Proceedings, Yichang, IEEE, 2011, p. 1047-1050. DOI: 10.1109/ICECENG.2011.6057959. https://ieeexplore.ieee.org/abstract/document/6057959

Analysis of the Synergy Between Consumption and Residential Photovoltaic Production in the City of Três Lagoas – MS

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Abstract

The generation of electric energy, allocated to the low and medium voltage consumer, through primary energy sources or qualified cogeneration, called microgeneration, for powers up to 75 kW and minigeneration for installations up to 5 MW, according to resolution 482 of 2012 of the Agency of Electric Energy [1]. Despite being the focus of many studies today, in Brazil, there is still room for further analysis, especially on how the behavior of the electrical network will look when many consumers are making use of this technology. In this way, this work aims to contribute with a technical knowledge of the condition of the implantation of these energy systems. It is necessary that both the consumer and the concessionaire know well the behavior of their consumption and demand profile and the energy generated. In Brazil, the charging modality for micro and mini distributed generation is called "compensation" or "Net Metering", where there is no pecuniary remuneration for the generated energy, but credits are generated for later compensation, making an analogy, the energy network behaves like a “virtual battery” storing the surplus for later consumption [1].

In this way, understanding the relationship between the generation curve and the consumption curve, as well as the flows and exchange of energy is important for the management of the electrical grid and analysis of the feasibility of the power generation unit.

For this, in this work, a comparison was made between the expected load curve for a typical residential consumer, in the state of Mato Grosso do Sul, Brazil, as well as the comparison with the average generation curve for photovoltaic energy in the city of Três Lagoas, Mato Grosso. Grosso do Sul, Brazil.

The load curve was obtained from the methodology of the possession and habit survey carried out by Centrais Elétricas Brasileiras S.A. - Eletrobras estimated the hourly consumption profile and electrical equipment consumption of Brazilians and presented this data so that it is possible to survey the regional consumption curve, over a typical day [2]. In Figure 1, we have the estimate daily consumption information of the South-Mato-Grossense population

To estimate the photovoltaic solar generation, a solar system was simulated with the ability to meet this consumption in the System Advisor Model (SAM) software. The Software simulates the daily generation of a solar plant using local meteorological data. Data from the National Institute of Meteorology (INMET) were used.

In order to visualize the simultaneity between the simulated photovoltaic generation and the estimated load profile for the typical residence, the data were crossed and are presented in Figure 2. The data in Figure 2 can also be presented from a view of the energy exchange with the network, as shown in Figure 3. The positive direction of the vertical axis is considered to be the injection of power into the network (generation) and the negative direction of the axis vertical injection of power from the grid into the residential plant (consumption).

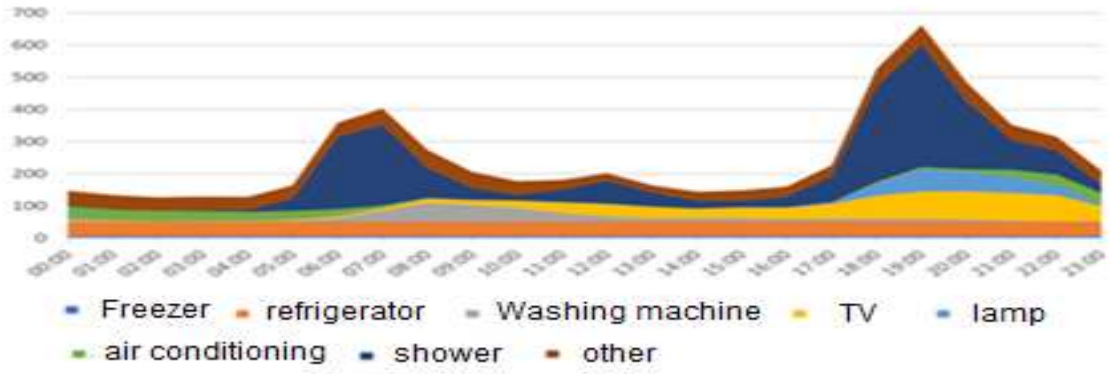

Figure 1 - Residential consumer load curve in Mato Grosso do Sul.

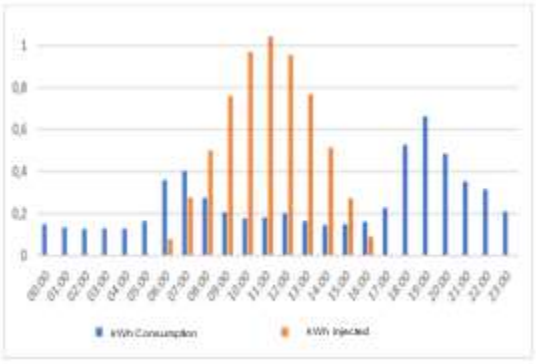

Figure 2 - Consumption and generation curves

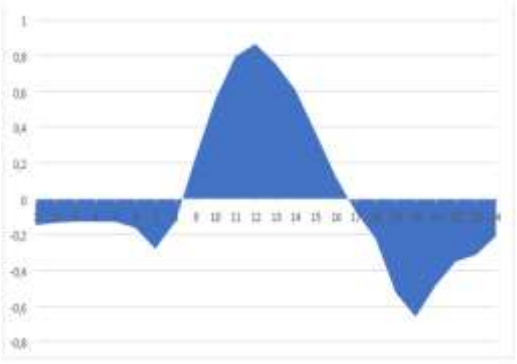

Figure 3 - Energy exchange.

We conclude that the production of photovoltaic solar energy, for the case studied, has its production and consumption peaks at different times, and that many times having to inject energy into the grid. The simultaneity was calculated around 50%. In other words, half of the energy generated is consumed in the consumer plant. Finally, it is worth mentioning that demand management measures can be applied to improve this factor, with a main focus on the electric shower, which is the most significant portion of the energy consumed outside of photovoltaic generation and can be replaced by alternative systems such as solar heaters, or have its use modulated by users.

Keywords: Load Curve.

References

[1] A THE NATIONAL ELECTRIC ENERGY AGENCY (ANEEL). Normative Resolution No. 482, of April 17, 2012. Establishes the general conditions for the access of microgeneration and distributed minigeneration to the electric energy distribution systems, the electric energy compensation system, and other measures. Official Gazette, Brasília section 1, p. 53, v. 149, no. 76, April 19, 2012,

[2] FEDERAL, Government. Pph 2019 web: Survey of Possession of Habits of Use of Electrical Equipment in the Residential Class. [S. l.], 2019.

Comparison Between the Analysis of Measured and Simulated Performance Ratio of Photovoltaic Microgeneration System

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Abstract

The Resolution of the Brazilian National Electric Energy Agency (ANEEL) number 482 of April 17, 2012, later updated and replaced by ANEEL Resolution number 687 of November 24, 2015, established the criteria for the modalities of minigeneration and microgeneration of electricity, which consists of installing small generators integrated to consumer units [1]. In this context, the Três Lagoas campus of the Federal Institute of Education, Science and Technology installed a microgeneration unit, with the purpose of generating energy in a more sustainable way and serving as a laboratory for teaching, research and extension.

The photovoltaic microgeneration unit at the Três Lagoas Campus of the IFMS went into full operation in April 2018 and has been in operation for just over 4 years. During that time, a series of studies were carried out on the system performance indices, dirt effect, cleaning, all in order to guide the maintenance and operation of the photovoltaic microgeneration unit and provide subsidies for the dissemination of knowledge. The unit has a generation capacity of 71.5 kWp, provided by 260 photovoltaic modules of 275 Wp, distributed in five inverters, of 15 kWp. Four of these invertersare powered by a roof system and one is powered by a ground system. Figure 1 shows an image of the system [2].

Figure1 - The photovoltaic microgeneration unit at the Três Lagoas Campus of the IFMS. [2]

To evaluate the performance of the microgeneration unit, two figures of merit were used, the "yield" and the "performance ratio" obtained by equations 1 and 2 respectively [2].

$$\text{yield} = \frac{energia\ (kWh)}{potência\ instalada\ (kWp)} \quad (1)$$

$$\text{performance ratio} = \frac{yield}{(radiation\ (\frac{kWh}{m^2}))1000} \quad (2)$$

Two figures of merit were raised. A measured performance ratio, using the radiation raised by a reference cell, and a "simulated" performance ratio using historical radiation data through the RADIASOL® software. The results can be seen in table 1.

Ano	**2018**	**2019**	**2020**	**2021**	**2022**
irradiation kWh/m2	1238,89	1892,85	1889,78	1914,43	856,84
Irradiation by RADIASOL® kWh/m2	1294,11	1837,94	1837,94	1837,94	820,78
Photovoltaic production kWh	78480	104390	99940	95570	44280
Yield (kwh/kWp)	1097,62	1460	1397,76	1336,64	619,3
Measured performance	88,59	77,13	73,96	69,82	72,27
Simulated performance	84,81	79,43	76,05	72,72	75,45

Tab 1. Results.

A comparative graph between the measured and simulated performance ratio is presented in figure 2.

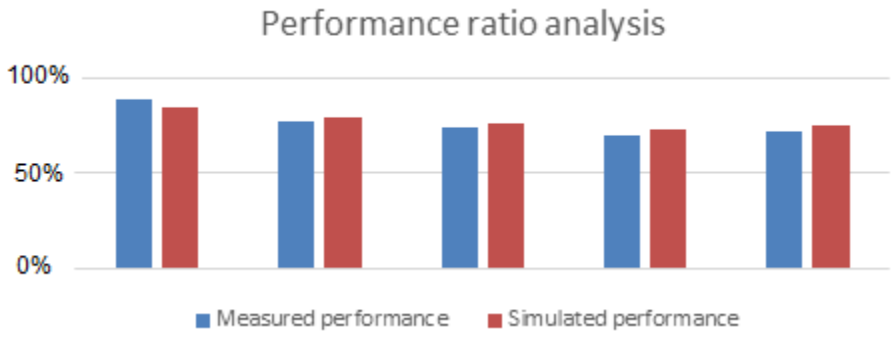

Figure 2 - Performance ratio analysis.

As a conclusion, there is a 98.3% similarity between the rare performance obtained by measuring the reference cell and the performance simulated with historical data by the RADIASOL software, so the simulated analysis can be a reference for systems that do not have a radiation measuring station.

Keywords: Performance Ratio, Photovoltaic, Yield.

References

[1] A THE NATIONAL ELECTRIC ENERGY AGENCY (ANEEL). Normative Resolution No. 482, of April 17, 2012. Establishes the general conditions for the access of microgeneration and distributed minigeneration to the electric energy distribution systems, the electric energy compensation system, and other measures. Official Gazette, Brasília section 1, p. 53, v. 149, no. 76, April 19, 2012,

[2] FRIGO, Murilo Miceno. SILVA, Larissa Kely da Luz. ESTUDO DA INFLUÊNCIA DA SUJIDADE SOBRE O RENDIMENTO DO SISTEMA DE MICROGERAÇÃO FOTOVOLTAICA, cap livro, Fontes Renováveis de energia: inovações, impactos e desafios, pag 15 -24. Disponível em: https://www.editoranavegando.com/livro-fontes-renovaveis-de-energia.

Biodiesel Production from Waste Cooking Oils Catalysed by Ionic Liquid [BMIM][HSO4]

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Abstract

The environmental and energy problems related to the burning of fuels from fossil resources, i.e. non-renewable fuels such as oil, natural gas or coal, leading to an increased concern about global warming, have directed the scientific community to seek sustainable and renewable energy alternatives. In this context, biofuels have emerged as a promising way to replace non-renewable fuels, including biodiesel [1]. Biodiesel is defined as a mix of monoalkyl esters of long fatty acid chains (FAMEs), and can be obtained by converting vegetable oils or animal fats through transesterification or esterification reactions. Due to its advantages, such as biodegradability, low viscosity, high flash point and low environmental impacts, it has potential to be used directly in diesel engines without any modification [2]. The raw materials used in biodiesel production can be divided into edible and inedible. However, the high cost of edible oils, which correspond to about 70% of the total value of production, as well as competition with the food market and soil degradation due to large planting scales, are disadvantages for the production and commercialization of biodiesel [3]. Inedible materials such as Waste Cooking Oils (WCOs) can also be used. The reuse of WCOs is a sustainable and environmentally friendly solution, preventing millions of tons of this raw material from being dumped into sanitation systems giving rise to serious problems in wastewater treatment. Still, one of the disadvantages of using WCOs is its high Free Fatty Acid (FFA) content that leads to saponification reactions [2]. Homogeneous alkaline catalysts are the most used in the biodiesel production industry. Compared to homogeneous acid catalysts, they have many advantages, such as high productivity, low price, allow high reaction speed, shorter reaction time, low alcohol molar ratio:oil and lower corrosiveness. However, catalysis is mainly affected by the presence of free fatty acids, leading to decreased reaction yields. In addition, when using these conventional catalysts, a high amount of clean water is used during the purification process, resulting in high flows of waste water, which is deposited in rivers, lakes, seas, contaminating the environment. To solve this problem, the possibility arises of using new catalysts, such as ionic liquids (ILs), which allow high reaction yields, and can be recovered and reused, making them greener and more economical [4].

Table 1 - ANOVA table for R1.

Source	Sum of squares	df	Mean Square	Calculated F-value	Tabulated F-value	p-value	
Model	1524.8916	14	108.9208	5.6959	2.637	0.0023	significant
Residual	229.4730	12	19.1228				
Lack of Fit	223.2512	10	22.3251	7.1764	19.396	0.1284	not significant
Pure Error	6.2218	2	3.1109				
Cor. Total	1754.3647	26					

Hence, the objective of this work is to assess the potential use of IL [BMIM][HSO_4] in the catalysis of esterification/transesterification reactions of a WCOs with simulated high FFAs content. For this purpose a Response Surface Methodology (RSM) from a Box-Behnken Design (BBD) was applied. Design Expert

11 software was used for the construction of this BBD and a matrix with four factors with three levels and two extra central points was generated. The chosen factors were: percentage of incorporated oleic acid (OA) (20, 40 and 60%wt), oil/methanol molar ratio (1:5, 1:10 and 1:15), catalyst dosage (5, 10 and 15%wt) and reaction time (2, 4 and 6 h). A set of 27 runs was established to quantify the influence of each factor on the two responses: acidity reduction (R1) and FAME content (R2). R1 was estimated by acid-base titrimetry and R2 was measured by GC-FID using the internal standard method. A temperature of 65°C was maintained during all reaction tests. The ANOVA tables for R1 and R2 are presented in Tables 1 and 2, respectively.

Table 2 - ANOVA table for R2.

Source	Sum of squares	df	Mean Square	Calculated F-value	Tabulated F-value	p-value	
Model	1897.65	14	135.55	48.92	2.637	< 0.0001	significant
Residual	33.25	12	2.77				
Lack of Fit	32.74	10	3.27	12.92	19.396	0.0739	not significant
Pure Error	0.5067	2	0.2533				
Cor. Total	1930.9	26					

The following models represented below correspond also to responses R1 and R2, respectively:

$$\mathbf{Y} = 37.11 + 0.896A + 2.16B + 5.53C + 8.35D + 1.29A^2 - 2.62B^2 - 2.19C^2 - 0.3637D^2 + 0.7637AB - 2.42AC - 0.1389AD + 83.15BC + 5.71BD + 1.61CD \quad (1)$$

$$\mathbf{Y} = 26.23 + 1.02A - 0.2917B + 0.8225C + 10.08D - 3.95A^2 - 9.54B^2 - 4.61C^2 - 3.09D^2 + 1.91AB - 5.41AC + 0.055AD + 1.05BC + 0.8BD + 2.11CD \quad (2)$$

For both responses, the most significant and relevant parameter was the incorporation of OA, followed by the molar oil/methanol ratio and catalyst dosage. The optimal conditions that present the best conversion values in terms of acidity reduction and FAME content were defined. The optimal conditions for acidity reduction were: reaction time of 2 hours, catalyst dosage of 15%wt, oil/methanol molar ratio of 1:15, and incorporation of OA of 60%wt, for a value of 58.1%. A percentage of 33.7% was found in the FAME content response at the following optimised conditions: reaction time of 4 h, catalyst dosage of 10%wt, molar oil/methanol ratio of 1:12, and incorporation of OA of 60%.

Keywords: Biofuel, Biodiesel, Ionic Liquid Catalyst, Esterification.

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References

[1] D. Z. Troter, Z. B. Todorović, D. R. Đokić-Stojanović, O. S. Stamenković and V. B. Veljković, "Application of ionic liquids and deep eutectic solvents in biodiesel," *Renewable and Sustainable Energy Reviews*, vol. 61, pp. 473–500, 2016, doi:10.1016/j.rser.2016.04.011.

[2] O. Yaakob, M. Mohammad, M. Alherbawi and Z. Alam, "Overview of the production of biodiesel from waste cooking oil," *Renewable and Sustainable Energy Reviews*, vol. 18, pp. 184–193, 2013, doi:10.1016/j.rser.2012.10.016.

[3] W. Xie and H. Wang, "Immobilized polymeric sulfonated ionic liquid on core-shell structured Fe_3O_4/SiO_2 composites: A magnetically recyclable catalyst for simultaneous transesterification and esterifications of low-cost oils to biodiesel," *Renewable Energy*, vol. 145, pp. 1709–1719, 2020, doi:10.1016/j.renene.2019.07.092.

[4] J. M. Fonseca, J. G. Teleken, V. Almeida and C. Silva, "Biodiesel from waste frying oils: Methods of production and purification," *Energy Convers. Manag.*, vol. 184, pp. 205–218, 2019, doi:10.1016/j.enconman.2019.01.061.

Valorisation of Waste Cooking Oils through Conversion Processes to Biodiesel Catalysed by Ionic Liquid [HMIM][HSO4]

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Abstract

To date, fossil fuels prevail as the primary source of energy, with a high consumption in transport and industries, making them a major problem for our planet, given its weak environmental sustainability due to its high greenhouse gas emissions to the atmosphere and the limited reserves [1]. In this context, biodiesel emerges as a biofuel, biodegradable, environmentally sustainable and less toxic when compared to fossil diesel, which has been acquiring much attention over the years, and it has been used commercially blended with diesel. Chemically it can be defined as a mix of fatty acid methyl esters (FAME), produced through transesterification reactions of vegetable oils or animal fats, with an alcohol, usually methanol, in the presence of basic catalysts, which are highly corrosive and difficult to recover [2]. Therefore, conventional catalysts present several problems for the environment, and for this reason, there is a need to develop more environmentally friendly catalysts. Ionic Liquids (IL) have attracted a lot of attention in recent decades, presenting themselves as the main alternative to traditional catalysts, being green, non-toxic and non-flammable solvents [3]. On the other the production of 1st generation biodiesel using raw materials from edible vegetable oils such as palm oil, sunflower oil, rapeseed oil, among others, has the potential of causing socio-economic conflicts since these oils compete directly with the food sector. This promoted the search for alternatives, such as the use of waste cooking oils (WCO), since it is a residue that can be reused and with high energy content. However, these processes still need better studies, due to the problems associated with the production through transesterification, with regard to the high content of Free Fatty Acids [1].

Hence, the objective of this work is the study of the application of the IL 1-methylimidiazolium hydrogen sulfate ([HMIM][HSO_4]) in the catalysis of esterification/transesterification reactions of a WCOs with high free fatty acids contents, through the application of a Response Surface Methodology (RSM) based in a Box-Behnken Design (BBD) in order to determine the optimal reaction conditions (reaction time, catalyst dosage, molar ratio methanol:oil and incorporation of oleic acid (OA) in WCO to simulate an oil with high acidity) for the esterification reaction of waste cooking oil with methanol.

Table 1 - ANOVA table for R1.

Source	Sum of squares	df	Mean Square	Calculated F-value	Tabulated F-value	p-value	
Model	7495.56	14	535.40	218.70	2.637	3.21×10^{-12}	significant
Residual	29.38	12	2.45				
Lack of Fit	29.05	10	2.90	17.74	19.40	0.0545	not significant
Pure Error	0.33	2	0.16				
Cor. Total	7524.94	26					

Design Expert 11 software was used for the construction of the BBD. An experimental design was used to generate a matrix with four factors with three levels and two extra central points. The chosen factors were: percentage of incorporated OA (20, 40 and 60% wt), oil/methanol molar ratio (1:5, 1:10 and 1:15),

catalyst dosage (5, 10 and 15% wt) and reaction time (2, 4 and 6 h). Through this methodology a set of 27 runs was established to quantify the influence of each factor on the two responses: acidity reduction (R1) and FAME content (R2). Acidity reduction was estimated by acid-base titrimetry and FAME content was measured by GC-FID using the internal standard method. A temperature of 65°C was maintained during all reaction tests. In Tables 1 and 2, the ANOVA tables for R1 and R2 are presented, respectively.

Table 2 - ANOVA table for R2.

Source	Sum of squares	df	Mean Square	Calculated F-value	Tabulated F-value	p-value	
Model	1941.39	14	138.67	22.13	2.637	2×10^{-6}	significant
Residual	75.21	12	6.27				
Lack of Fit	73.88	10	7.39	11.10	19.396	0.0854	not significant
Pure Error	1.33	2	0.67				
Cor. Total	2016.60	26					

Corresponding to the following models represented by equations (1) and (2), also for responses R1 and R2, respectively:

$$Y = 45.92 + 10.18A + 1.56B + 21.87C - 3.56D - 3.59AB + 2.23AC - 2.20AD + 1.70BC - 0.2183BD - 4.21CD - 2.00A^2 + 0.0055B^2 - 1.65C^2 + 3.58D^2 \quad (1)$$

$$Y = 20.44 + 5.50 + 0.5500B + 7.76\mathrm{C} + 7.88D - 0.7125AB + 2.31AC + 3.09AD + 0.8975BC - 1.00BD + 1.77CD + 1.25A^2 + 0.9925B^2 - 0.8500C^2 - 0.5250D^2 \quad (2)$$

For response R1, the most significant factor for the conversion was the molar ratio oil/methanol, followed by the reaction time and then by the OA incorporation, while for response R2, the most relevant factor was the incorporation of OA, followed by the molar ratio oil/methanol and finally by the reaction time. For both responses, the least significant factor was the catalyst dosage. The ideal conditions for acidity reduction were: reaction time at 6 h, catalyst dosage at 5 %wt, molar ratio oil/methanol for 1:20 and 20 %wt OA incorporation, leading to a conversion of 76.70 %. The optimal conditions, which leads to the highest FAME content of 42.02 %wt were estimated at 6 h of reaction time, 15 %wt of catalyst dosage, molar ratio oil/methanol for 1:20 and 60 %wt of OA incorporation.

Keywords: Biofuels, Biodiesel, Ionic Liquid Catalyst, Esterification.

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References

[1] T. M. I. Mahlia, Z. A. H. S. Syazmi, M. Mofijur, A. E. Pg Abas, M. R. Bilad, H. C. Ong and A. S., Silitonga, "Patent landscape review on biodiesel production: technology updates," *Renewable and Sustainable Energy Reviews*, vol. 118, p. 109526, 2020, doi:https://doi.org/10.1016/j.rser.2019.109526.

[2] Q. Wu, H. Chen, M. Han, D. Wang and J. Wang, "Transesterification of cottonseed oil catalyzed by Brønsted acidic ionic liquids," *Ind. Eng. Chem. Res.*, vol. 46, no. 24, pp. 7955–7960, 2007, doi:https://doi.org/10.1021/ie070678o.

[3] Z. Ullah, M. Azmi Bustam, Z. Man, A. S. Khan, N. Muhammad and A., Sarwono, "Preparation and kinetics study of biodiesel production from waste cooking oil using new functionalized ionic liquids as catalysts," *Renewable Energy*, vol. 114B, pp. 755–765, 2017, doi:https://doi.org/10.1016/j.renene.2017.07.085.

Modeling Residual Wood Biomass Yield in the Sub-Regions Terras de Trás-os-Montes and Aveiro

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Abstract

With the purpose of evaluating the potential of annual biomass production, we used statistical modeling based on Land Use and Land Cover (COS2018) [1] and 5th National Forest Inventory [2] data to simulate yield and growth of maritime pine in Terras de Trás-os-Montes sub-region (30.02% of forest cover) and eucalyptus in the Aveiro sub-region (77.24% of forest cover) under different management scenarios.

We developed a software tool (the Stochastic Forest Simulator) inspired in AppTitude® [3] software incorporating the forest growth and yield equations of FlorNext® [4] for maritime pine and the model GLOBULUS 3.0 [5] for eucalyptus. The scenarios were built based on the Regional Forest Management Program of Trás-os-Montes and Alto Douro [6] for maritime pine and on the variables used in the GLOBULUS 3.0 model for eucalyptus in Aveiro. The conversion of volume to biomass was done using the specific mass of the species and the residual biomass considering 28% of the volume for maritime pine and 25% of the volume for eucalyptus [7]. The results of the 6th National Forest Inventory [8] were used to validate the model.

All scenarios, optimistic and pessimistic, produced results within the ±27.2% confidence interval established based on error. The highest values of potential residual biomass from the stands of maritime pine were observed in scenarios where there was no application of thinning (highest production in scenario 16 with 1.05Tg) at the end of the 50-year period of the simulations. The average residual biomass for the standing forest in the first year of the simulations represented 11.3% of the estimated annual consumption of 2,294,000Mg of biomass in the country [9]. The scenarios without thinning also showed the highest residual biomass in final cuts (CV = 1.27%). For thinning residues, the highest production was observed under strong thinning interventions and several periods, with an average of 261.75Mg in the first year and 3,600.65Mg in the last simulated year.

The scenario of higher potential residual biomass production for eucalyptus generated 699,417.97Mg (0.794Mg/m^3) and 409,608.76Mg (0.465Mg/m^3). The highest residual biomass in final eucalyptus fellings at the end of the simulation period was 3,317,022.67Mg and 1,942,588.84Mg for the two specific mass values considered. Residual biomass in standing eucalyptus corresponded to 60.7% (higher specific mass) or 35.5% (lower specific mass) of national consumption in the first year of the simulations and the annual average of residual biomass from final cuts to 12.5% (higher specific mass) or 7.3% (lower specific mass).

Keywords: Growth and Yield Modeling and Simulation, Maritime Pine, Eucalyptus, Residual Biomass, Scenarios.

References

[1] Direção Geral do Território, "Carta de Uso e Ocupação do Solo - 2018," 2019. https://snig.dgterritorio.gov.pt/rndg/srv/por/catalog.search#/metadata/b498e89c-1093-4793-ad22-63516062891b?tab=responsible (accessed Oct. 06, 2020).

[2] Autoridade Florestal Nacional, "Inventário Florestal Nacional – Portugal Continental. IFN5 2005-2006 Relatório Final," 2010, Lisboa, Portugal, p. 209.

[3] F. Pérez-Rodríguez and J. C. Azevedo, "Evaluation of Forest Industry Scenarios to Increase Sustainable Forest Mobilization in Regions of Low Biomass Demand," Applied Sciences, vol. 10, no. 18, p. 6297, Sep. 2020, doi: 10.3390/app10186297.

[4] F. Pérez-Rodríguez, L. Nunes, Â. Sil, and J. Azevedo, "FlorNExT®, a cloud computing application to estimate growth and yield of maritime pine (Pinus pinaster Ait.) stands in Northeastern Portugal," Forest Systems, vol. 25, no. 2, p. eRC08, Jul. 2016, doi: 10.5424/fs/2016252-08975.

[5] M. Tomé, T. Oliveira, and P. Soares, "O modelo GLOBULUS 3.0 dados e equações," Instituto Superior de Agronomia. Departamento de Engenharia Florestal, 2006. Accessed: Nov. 03, 2020. [Online]. Available: https://www.repository.utl.pt/handle/10400.5/1760

[6] Diário da República Eletronico, "Portaria 57/2019 Diário da República nº29/2019 - 1.a série. Programa Regional de Ordenamento Florestal de Trás-os-Montes e Alto Douro," https://dre.pt/dre/detalhe/portaria/57-2019-119386290 (accessed Oct. 14, 2020).

[7] J. Cunha and A. Marques, "Caracterização das cadeias de abastecimento de biomassa florestal em Portugal, Parte I - Análise de fluxos e de capacidade instalada para processamento da biomassa florestal em Portugal I," p. 59, 2019.

[8] Instituto da Conservação da Natureza e das Florestas, "6º Inventário Florestal Nacional- Resultados NUTSIII," 2019.

[9] Navigator, "A importância da Biomassa - Dia Internacional das Florestas," 2018. https://www.apren.pt/contents/documents/frederico-pisco.pdf (accessed Oct. 14, 2020).

Study of Biodiesel Production from Waste Cooking Oil by Ethyl Transesterification and its Purification Using Adsorption Processes

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Abstract

In recent years, a collective effort is made in search of alternative forms of energy through renewable and more friendly to the environment sources, currently, about 80% of the world consumption of energy comes from fossil fuels. The environmental problems associated with the use of these non-renewable fuels include air pollution and global warming, moreover, the uncertain price of a barrel of oil in the current economy also causes economic problems in its dependence. Thus, due to these problems in the dependence on fossil fuels for industry, transport and domestic purposes, research on alternative energy sources has become ever more common [1]. In this scenario, biodiesel presents itself as a renewable fuel, environmentally friendly and with similar characteristics to common diesel.

According to [2] in 2020, global biodiesel production reached 46.45 million tons, with biodiesel from waste cooking oils (WCO) constituting approximately 10% of this total, with Europe accounting for approximately 33% and Brazil 12% of global production. The cost of conventional biodiesel production is higher than the production of diesel from petroleum, since it is produced mainly from high quality virgin oils, it is estimated that 70 to 80% of the total cost of biodiesel production is associated with the cost of their raw materials [3]. With this perspective, biodiesel production from WCO has become an economic opportunity and an environmental strategy to help address global renewable energy challenges and contribute to a sustainable society [4]. Oil with hours of frying at high temperatures results in the loss of its edible properties and nutritional value, the disposal of used cooking oil remains an issue due to its environmental and human health threats, countries are now imposing penalties and restrictions on the disposal of this cooking waste in drainage systems and/or natural water bodies [5]. In this scenario, the collection and destination of these oils for the production of a value-added and environmentally friendly biofuel presents itself as an opportunity to be investigated.

Transesterification is the most used method to reduce the viscosity of vegetable oils through their conversion into biodiesel. It is a process by which alkyl esters are produced from chemical reactions between an alcohol and vegetable oils in the presence of a catalyst. The most accessible and available alcohols for this reaction include methanol and ethanol [6]. Among the purification processes, the wet wash method, which uses water or acidified water to purify the esters, is the most commonly used [7]. Despite being an efficient method, wet washing generates huge amounts of wastewater that need to be treated to be discharged into sewer systems. On average, for each litre of purified biodiesel, the amount of water needed for purification varies from 0.2 to 10 litres [7]. In addition to the environmental inconvenience, wet washing is also energy and time consuming and economically inefficient. The literature indicates that effluent treatment costs between 0.09 and 3.8% of the total cost of production [7]. Adsorption and ion exchange are the most commonly used affinity separation processes worldwide, these methods are also known as dry washing methods. In these processes, an appropriate adsorbent is used to selectively adsorb certain impurities from the liquid phase onto its surface. Dry cleaning offers several advantages over wet cleaning, including ease of integration into an existing plant, shorter purification time, lower water consumption and lower effluent generation [8]. Some cellulosic and

lignocellulosic materials present characteristics of adsorbents for the purification of biodiesel [9]. These materials are abundant in nature, easy to acquire and of low value, in addition to their advantages as renewable and non-toxic materials [10]. Activated Carbon (AC), activated fibre (carbon fibre) and activated alumina are among the most common adsorbents in industrial applications. AC, which has a large porous volume and high surface area, can be manufactured from any organic material rich in carbon, such as: sawdust, petroleum coke, wood, coal, peat, fruit nuts, bituminous coal, lignite, coconut husks and olive stones [8].

In this work, an optimization of the production of biodiesel from a WCO by the ethylic route is sought, through its characterization and purification by adsorption using natural adsorbents, focusing on the removal of glycerine. In the preliminary results, some required conditions for the production were found, such as the minimum concentration of catalyst which was established at 1% (wt/wt) and better yields at lower temperatures. Next step will be the construction of a response surface methodology for the test of 3 parameters: alcohol:oil molar ratio, reaction temperature and catalyst concentration. Subsequently the synthesis of adsorbent materials based on natural sources, such as olive stones, will be carried out for application in the adsorption tests for biodiesel purification.

Keywords: Biofuel, Biodiesel, Purification, Adsorbents.

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References

[1] E. Arenas, S. M. Villafán-Cáceres, Y. Rodríguez-Mejía, J. A. García-Loyola, O. Masera and G. Sandoval, "Biodiesel dry purification using unconventional bioadsorbents," *Processes*, vol. 9, no. 2, pp. 1–12, Feb. 2021, doi: 10.3390/pr9020194.

[2] JOPA, *Data from ISTA Mielke's Oil World Annual Report and Other Editions*, Japan Oilseed Processors Association (JOPA), Tokyo, 2020, https://www.oil.or.jp/kiso/seisan/seisan03_02.html (Accessed April 14, 2022).

[3] R. Ahmed and K. Huddersman, "Review of biodiesel production by the esterification of wastewater containing fats oils and grease (FOGs)," *Journal of Industrial and Engineering Chemistry*, vol. 110, pp. 1–14, June 2022, doi: 10.1016/j.jiec.2022.02.045.

[4] C. Chen, A. Chitose, M. Kusadokoro, H. Nie, W. Xu, F. Yang and S. Yang, "Sustainability and challenges in biodiesel production from waste cooking oil: An advanced bibliometric analysis," *Energy Reports*, vol. 7, pp. 4022–4034, Nov. 2021, doi:10.1016/j.egyr.2021.06.084.

[5] S. Nanda, R. Rana, H. N. Hunter, Z. Fang, A. K. Dalai and J. A. Kozinski, "Hydrothermal catalytic processing of waste cooking oil for hydrogen-rich syngas production," *Chemical Engineering Science*, vol. 195, pp. 935–945, Feb. 2019, doi: 10.1016/j.ces.2018.10.039.

[6] M. M. K. Bhuiya, M. G. Rasul, M. M. K. Khan, N. Ashwath and A. K. Azad, "Prospects of 2nd generation biodiesel as a sustainable fuel - Part: 1 selection of feedstocks, oil extraction techniques and conversion technologies," *Renewable and Sustainable Energy Reviews*, vol. 55, pp. 1109–1128, Mar. 2016, doi: 10.1016/j.rser.2015.04.163.

[7] M. Catarino, E. Ferreira, A. P. Soares Dias and J. Gomes, "Dry washing biodiesel purification using fumed silica sorbent," *Chemical Engineering Journal*, vol. 386, p. 123930, Apr. 2020, doi: 10.1016/j.cej.2019.123930.

[8] H. Bateni, A. Saraeian and C. Able, "A comprehensive review on biodiesel purification and upgrading," *Biofuel Research Journal*, vol. 4, no. 3, pp. 668–690, Jun. 2017, doi: 10.18331/BRJ2017.4.3.5.

[9] M. G. Gomes, D. Q. Santos, L. C. de Morais and D. Pasquini, "Purification of biodiesel by dry washing, employing starch and cellulose as natural adsorbents," *Fuel*, vol. 155, pp. 1–6, Sep. 2015, doi: 10.1016/j.fuel.2015.04.012.

[10] H. Bateni and K. Karimi, "Biodiesel production from castor plant integrating ethanol production via a biorefinery approach," *Chemical Engineering Research and Design*, vol. 107, pp. 4–12, Mar. 2016, doi: 10.1016/j.cherd.2015.08.014.

Biodiesel Production from Residual Cooking Oils and Purification by Adsorption Processes Based on Adsorbents of Natural Origin

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Abstract

Total global energy consumption has increased significantly in recent decades. International Energy Agency predicts that from 2012 to 2040, and also the International Energy Agency (IEA), by 2030, the world's demand for energy will increase by 50%. Nowadays, the main sources of energy supply in the world are oil, coal and natural gas. In addition to the environmental problems, the supply of fossil fuels is limited, which makes many researchers increasingly interested in exploring alternative energy sources [1].

In this pursuit, biofuels are promising renewable energy sources with lower carbon emissions, besides the possibility of being made from a variety of resources, including residues such as waste cooking oil (WCO), oily sludge from factories, and discarded animal fats [2]. In contrast to petroleum-derived diesel, biodiesel is renewable, biodegradable, non-toxic, sulphur-free and aromatic carcinogen-free [3].

The cost of biodiesel is now 10% to 50% higher than petroleum diesel. A more possible way to increase biodiesel production is to use WCO as a feedstock, which is 25% to 40% of the price of edible oil. This way, WCO gets a better destination than its discard [3].

Biodiesel is produced through transesterification/esterification which are reactions that convert oils or free fatty acids into alkyl esters. Through transesterification, the triglycerides react with small chain alcohol in order to obtain methyl or ethyl esters of fatty acids and glycerol. The process occurs in three reversible and consecutive reactions, which produce molecules of diglycerides and monoglycerides as intermediates [4].

The properties of biodiesel will depend on the feedstock used in its production, and it should be similar to petroleum diesel in order to be functional in motors without any changes. All parameters, such as cetane number, fatty acid methyl esters content, density, and acid value, are defined by standards and vary depending on the location. For example, in Europe, they are defined by the European Biodiesel Standard EN 14214, whose last version was published in 2008. It is set to specify characteristics that define the behaviour of biodiesel combustion in an engine and also the methods that have to be used to determine those parameters [5].

In order to attend to all the specifications presented at EN 14214, the produced biodiesel has to pass through a purification process. The purification process is important to remove the impurities present in the final product, such as the alcohol excess, glycerol, among others.

In this work, the chosen process to purify the produced biodiesel is adsorption, the phenomenon in which a solute is attached to a solid surface. It is widely used in chemical and biochemical processes to recovery or removal of certain substances. The solid surface where the adsorption takes place, the adsorbent, is usually a porous material with high surface area, and the substance that is been recovered is called adsorbate [6].

Several studies have been made related to biodiesel purification by adsorption. Materials like silicates,

clays, polymers among others are widely used as adsorbents. They have acid or basic adsorption sites that have a strong affinity with polar compounds such as ethanol, glycerol, metals and soap [7].

Combining the need for purification of biodiesel and the proposal of reuse of waste oils, cork residues will be studied as a potential adsorbent, as it is a porous material with a large surface area. For the purpose of comparing efficiency, a commercial adsorbent will also be tested, since previous studies proved its high efficiency in the purification of liquid effluents.

The first stage of the research is the optimization of biodiesel production. The influence of factors like oil:alcohol proportion, catalyst load and reaction temperature, in the transesterification of a WCO sample with ethanol have been studied.

The first parameter, oil:alcohol proportion, was studied at the values of 1:6 and 1:9. The results obtained show that 1:6 is favoured at lower temperatures, in a range of 30-35°C. When the temperature is higher, above 45°C, the process needs a higher proportion of oil:alcohol in order to allow the separation of the two phases, otherwise, it will form only one phase since the biodiesel does not separate from glycerol.

For the catalyst load, it was studied at 0,5% and 1% (wt/wt) in relation to the oil mass. At lower temperatures, both tests provide satisfactory results, but at higher temperatures, the best result was obtained at the higher catalyst load.

Hereafter, it is intended to produce activated carbons from cork residues samples in order to study the efficiency of glycerol removal non-activated from different samples of crude ethylic biodiesel, synthesized with the optimal conditions of oil:alcohol proportion, catalyst load and reaction temperature. A commercial adsorbent and granulated cork will also be studied, for the comparison of the adsorption performance with the previous materials and literature data.

Keywords: Biodiesel, Biodiesel purification, Adsorption.

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References

[1] S. N. Gebremariam and J. M. Marchetti, "Economics of biodiesel production: Review," *Energy Conversion and Management*, vol. 168, pp. 74–84, July 2018, doi:10.1016/j.enconman.2018.05.002.

[2] K. V. Raghavulu, S. Uppalapati, A. N. Kumar, S. P. Jani, A. Rajalingam and N. G. Rasu, "Effect on performance and emission of canola oil and snake gourd oil biodiesel blended in fossil diesel-biodiesel blend," *Materials Today: Proceedings*, vol. 37, no. 2, pp. 1091–1095, 2021, doi:10.1016/j.matpr.2020.06.338.

[3] L. Liu, B. Mu, W. Li, H. Xu, J. Yang and Y. Yang, "Clean cotton dyeing in circulated dyebath of waste cooking oil: A feasible industrialization strategy for pollution minimization," *Journal of Cleaner Production*, vol. 278, p. 123799, Jan. 2021, doi:10.1016/j.jclepro.2020.123799.

[4] F. Moazeni, Y.-C. Chen and G. Zhang. "Enzymatic transesterification for biodiesel production from used cooking oil, a review," *Journal of Cleaner Production*, vol. 216, pp. 117–128, April 2019, doi:10.1016/j.jclepro.2019.01.181.

[5] M. Carmona-Cabello, I. L. García, A. Papadaki, E. Tsouko, A. Koutinas and M. P. Dorado, "Biodiesel production using microbial lipids derived from food waste discarded by catering services," *Bioresource Technology*, vol. 323, p. 124597, March 2021, doi:10.1016/j.biortech.2020.124597.

[6] L. Yu, L. Zhang and Y. Sun, "Protein behavior at surfaces: orientation, conformational transitions and transport," *Journal of Chromatography A*, vol. 1382, pp. 118–134, Feb. 2015, doi:10.1016/j.chroma.2014.12.087.

[7] H. Bateni, A. Saraeian and C. Able, "A comprehensive review on biodiesel purification and upgrading," Biofuel Research Journal, vol. 4, no. 3, pp. 668–690, Sept. 2017, doi:10.18331/BRJ2017.4.3.5.

Biomass Characterization and Pyrolysis, the Effect of Heating Rate on Products Yield

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Abstract

Biomass is widely recognized as one of the main potential sources for renewable and sustainable generation of fuels, chemicals and other carbon-based materials for a long time. According to International Energy Agency, biomass energy accounts for about 14% of the world's total primary energy supply in 2017. There are many advantages in using biomass as an energy source, namely its carbon neutrality and being a non-polluting energy source. Many processes can be used to obtain fuels and chemicals from biomass, and the pyrolysis process is a renewable, economical, and efficient way to produce energy [1].

Pyrolysis is one of the main technologies for biomass conversion into energy. It consists of a thermal decomposition process in an inert atmosphere with absence of oxygen, to convert biomass into biochar (solid fraction), bio-oil (liquid fraction) and gases. Pyrolysis is a recognized industrial process for biomass conversion. No waste is generated in the process, as the bio-oil and biochar can each be used as a fuel and as fertilizer respectively, and the gases can be recycled back into the process [2].

A biomass sample (pellets) was characterized by proximate analysis, determining the fixed carbon (F.C.), moisture, volatiles and ashes composition, and by ultimate analyses, determining the content of C, H, N, S and O. The content of hemicellulose, lignin and cellulose was also determined. The methodologies are described elsewhere [3]. All characterizations were performed on a dry basis, at the conditions in which the sample was previously dried. Pyrolysis tests were performed in a fixed-bed vertical pyrolysis oven, with a maximum temperature of 500 °C, a heating rate of 10, 20, 35 and 40 °C/min, a retention time of 0.5 h and an N_2 flow of 20 mL/min. The bio-oil produced was qualitatively characterized using FTIR.

The results of the biomass ultimate and proximate characterization are shown in Table 1.

Table 1 - Biomass ultimate and proximate characterization results.

Biomass type	Volatile (wt%)	Ashes (wt%)	F.C. (wt%)	C (%)	H (%)	N (%)	S (%)	O (%)
Pellets	79.305	0.377	20.318	46.526	5.576	0.119	0.000	47.402

It is noteworthy that the composition of the pellets shows a low value for ashes, lower than 1 %, being a suitable feedstock for the pyrolysis, as a high concentration of ashes biomass could cause clogging of the equipment during the pyrolysis, due to the formation of big particle deposits. The volatile content, around 80 %, is in the same range as other biomass sources, and it is known that higher volatile matter content implies a higher amount of bio-oil production via pyrolysis [4]. According to the ultimate analysis, the average chemical formula of this biomass would be $C_1H_{1.42}N_{0.002}O_{0.76}$. The CHO index is a parameter that describes the oxidation state of organic matter and varies from -4 to +4. The CHO index is described in Equation (1), where [C], [H] and [O] are the molar ratios of the elements.

$$CHO_{index} = \frac{2*[O]-[H]}{[C]} \quad (1)$$

The analyzed biomass CHO index is 0.104. A CHO index above 0 indicates the presence of more oxidized

compounds on the sample, meaning that this biomass sample has a slightly high oxygen content whereas the hydrogen content is slightly low. The CHO index plays an important role in the quality of the bio-oil produced, as biomasses with a high CHO index are more likely to produce bio-oils concentrated with oxygen-rich compounds, lowering its quality.

The results of the biomass pyrolysis tests, with different heating rates, are shown in Table 2.

Table 2 - Products yields for the biomass pyrolysis tests.

Heating Rate (°C/min)	Biochar Yield (wt%)	Bio-oil Yield (wt%)	N.C.G.* Yield (wt%)
10	23.975	28.310	47.715
20	23.471	28.017	48.513
35	22.873	24.378	52.749
40	22.307	24.221	53.472

*N.C.G. = Non-condensable gases

The increment of the heating rate induced a difference in the products yields. For the solid and liquid fraction of the pyrolysis products, the increment of heating rate diminished the yield of those products, whereas raised the yield of the gas fraction. This phenomenon could be caused by the cracking of biomass components, as this is an endothermic reaction, therefore, the increase in heating rate could facilitate the cracking of heavy molecules to produce smaller ones, generating more gaseous particles at cost of solid and liquid yield [5].

Pyrolysis of the biomass proved to be a viable technology for the valorization of a worldwide produced waste, as biomass withal producing renewable energy. Bio-oil was successfully obtained by the pyrolysis of the biomass, with yields in the range of 24 to 28%. The heating rate proved to influence the yields of the products, for higher heating rates it is observed a bigger yield of N.C.G.s, meanwhile lower heating rates tend to prioritize the formation of biochar and bio-oil.

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Keywords: Pyrolysis, Biomass Valorization, Renewable Energy, Optimization.

References

[1] W. Cai, Z. Luo, J. Zhou and Q. Wang, "A review on the selection of raw materials and reactors for biomass fast pyrolysis in China," *Fuel Process. Technol.*, vol. 221, no. May, p. 106919, 2021, doi: 10.1016/j.fuproc.2021.106919.

[2] Y. Chhiti and M. Kemiha, "Thermal conversion of biomass, pyrolysis and gasification: A review," *Int. J. Eng. Sci.*, vol. 2, no. 3, pp. 75–83, 2013.

[3] C. Frau, F. Ferrara, A. Orsini and A. Pettinau, "Characterization of several kinds of coal and biomass for pyrolysis and gasification," *Fuel*, vol. 152, pp. 138–145, 2014, doi: 10.1016/j.fuel.2014.09.054.

[4] F. Lin, C. L. Waters, R. G. Mallinson, L. L. Lobban and L. E. Bartley, "Relationships between biomass composition and liquid products formed via pyrolysis," *Front. Energy Res.*, vol. 3, no. Oct., p. 45, 2015, doi: 10.3389/fenrg.2015.00045.

[5] J. Han and H. Kim, "The reduction and control technology of tar during biomass gasification/pyrolysis: An overview," *Renew. Sustain. Energy Rev.*, vol. 12, no. 2, pp. 397–416, 2008, doi: 10.1016/j.rser.2006.07.015.

Metal Oxide-Based Photoelectrocatalytic Materials for Overall Water Splitting: An Overview

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Abstract

The scientific community has been looking for ways to produce clean and renewable energy to reduce pollutant emissions on the planet. Energy demand to meet the technological and human development needs is increasing, making it necessary to obtain new forms of energy generation. For example, the use of wind and solar energy has been high over the years. This work presents an explanation of the use of electrocatalytic materials in the Water Splitting technique that can be used, for example, in the clean production of hydrogen [1].

Hydrogen can be a substitute for fossil fuels in energy production. Normally, H_2 production is done through fossil fuel combustion or other non-renewable sources, but it causes damage to the environment by polluting through residue emissions into the atmosphere. In recent years, research groups have been trying to develop some emission-free production systems to obtain green hydrogen. A complicating factor is that hydrogen is not naturally available in the environment, it's necessary to get it from substances/molecules that contain it using separation methods. Due to this, the overall water splitting electrochemical method can be used.

Molecular separation of water into O_2 and H_2 requires a certain amount of energy to be supplied to the system for the phenomenon to occur, because it does not occur spontaneously [2]. In theory, a Thermodynamic Equilibrium Potential (TEP) is enough for water separation. But in practice, a need to supply more energy to the system for the HER/OER (hydrogen and oxygen evolution reactions) occurs, to improve the low rate of evolution of the oxygen reaction is observed. This potential increase above the theoretical limit is called overpotential [3].

Materials with low overpotential, good stability and fast electrochemical kinetic have been pursued by researchers around the world. Some metal oxide-based materials have been proposed for fabricating electrodes with good electrocatalytic activity. This process uses a photoelectrochemical cell (PEC) capable of accelerating the HER and OER reactions in the system, using materials that have high current density and high catalytic efficiency, with the lowest possible overpotential [4].

Some materials like CoO [5], TiO_2 [6], CuO [7] were reported in the literature for use in water splitting technique and the research group of the Laboratory of Advanced Experimental Physics (LaFEA) has experience to manufacture electrodes from them. For example, CoO electrodes were manufactured and characterized by Cyclic Voltammetry (CV) as shown in Fig. 1, exhibiting good specific current and nano-sheet like formation [8].

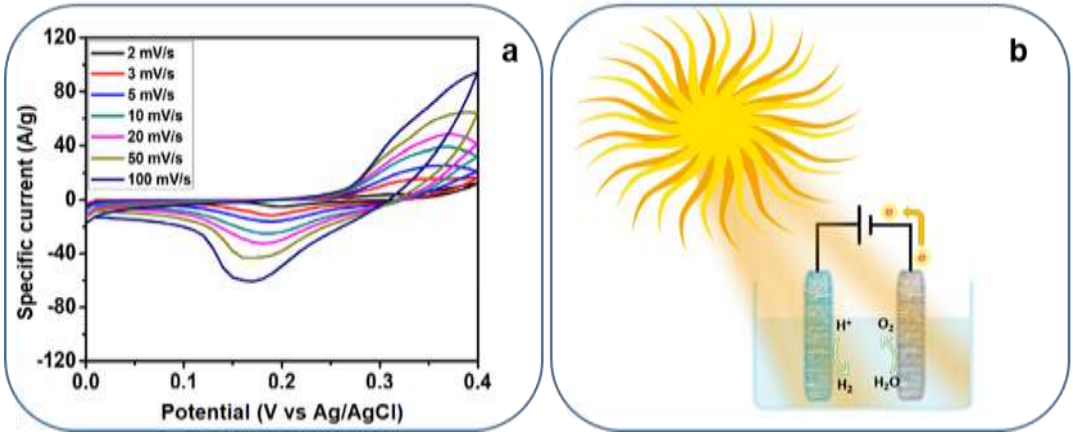

Figure 1 – CoO characterization by (a)CV [8] and (b) setup schematic of PEC water splitting.

In this work, some metal oxide-based materials have been presented and showed good electrochemical stability and high current density for overall water splitting applications. This indicates the possibility of using these materials in the production of green hydrogen.

Keywords: Water Splitting, Photoelectrocatalyst Materials, Hydrogen Production, Metal Oxide Electrodes.

References

[1] S. E. Hosseini and M. A. Wahid, "Hydrogen production from renewable and sustainable energy resources: Promising green energy carrier for clean development," Renewable and Sustainable Energy Reviews, vol. 57, pp. 850–866, May 2016, doi: 10.1016/j.rser.2015.12.112.

[2] H. Lund, "Renewable energy strategies for sustainable development," Energy, vol. 32, no. 6, pp. 912–919, Jun. 2007, doi: 10.1016/J.ENERGY.2006.10.017.

[3] J. Yu, Y. Dai, Q. He, D. Zhao, Z. Shao, and M. Ni, "A mini-review of noble-metal-free electrocatalysts for overall water splitting in non-alkaline electrolytes," Materials Reports: Energy, vol. 1, no. 2, p. 100024, May 2021, doi: 10.1016/j.matre.2021.100024.

[4] L.-M. Cao, D. Lu, D.-C. Zhong, and T.-B. Lu, "Prussian blue analogues and their derived nanomaterials for electrocatalytic water splitting," Coordination Chemistry Reviews, vol. 407, p. 213156, Mar. 2020, doi: 10.1016/j.ccr.2019.213156.

[5] X. Yu et al., "Highly disordered cobalt oxide nanostructure induced by sulfur incorporation for efficient overall water splitting," Nano Energy, vol. 71, p. 104652, May 2020, doi: 10.1016/j.nanoen.2020.104652.

[6] F. A. Jumeri, H. N. Lim, Z. Zainal, N. M. Huang, and A. Pandikumar, "Titanium dioxide-reduced graphene oxide thin film for photoelectrochemical water splitting," Ceramics International, vol. 40, no. 9, pp. 15159–15165, Nov. 2014, doi: 10.1016/J.CERAMINT.2014.06.130.

[7] R. Borkar, R. Dahake, S. Rayalu, and A. Bansiwal, "Copper Oxide Nanograss for Efficient and Stable Photoelectrochemical Hydrogen Production by Water Splitting," Journal of Electronic Materials, vol. 47, no. 3, pp. 1824–1831, Mar. 2018, doi: 10.1007/s11664-017-5966-y.

[8] R. S. Santos, R. Suresh Babu, M. Devendiran, D. B. Haddad, and A. L. F. de Barros, "Facile synthesis of transition metal (M = Cu, Co) oxide grafted graphitic carbon nitride nanosheets for high performance asymmetric supercapacitors," Materials Letters, vol. 308, p. 131156, Feb. 2022, doi: 10.1016/J.MATLET.2021.131156.

Construction and Characterization of Solar Cells Sensitized by Natural Dyes Extracted from Fruits and Flowers

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Abstract

Since the demand for energy is growing on the planet, alternatives are sought for the development of sustainable, efficient, and low-cost sources, such as photovoltaic solar energy. This type of technology consists of converting sunlight into electricity through photovoltaic cells composed of semiconductor materials, such as dye sensitized solar cells (DSSCs) [1-4].

Fig. 1(a) illustrates the working principle of DSSCs developed by LaFEA researchers and Fig. 1(b) presents its assembly scheme.

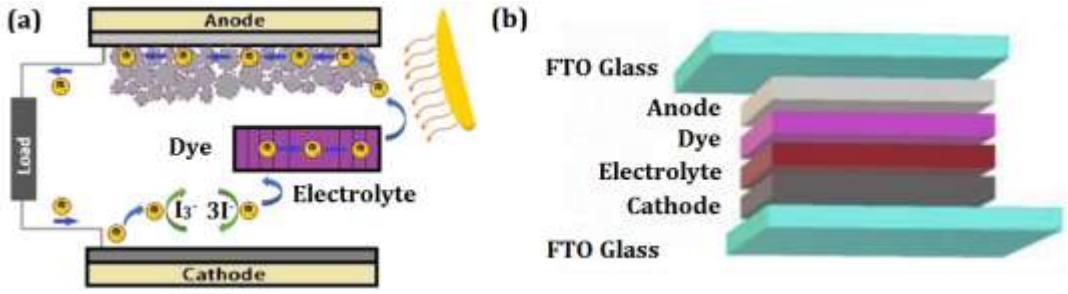

Figure 1 – DSSC operation (a) [2-7] and assembly scheme (b) [3-8]

Before the incidence of solar radiation, the dye molecules are in their low energy ground state (LUMO). At this moment, the semiconductor oxide (TiO_2, Nb_2O_5, CuO or ZnO) present on the anodic surface is submitted to the same non-conducting energy (near the valence band). When sunlight strikes the DSSC (oxidizing part), the dye molecules are excited and leave their low energy ground state and go to a higher energy state (HOMO). Therefore, the excited dye molecules have a higher energy content, overcoming the valence band difference of the semiconductor, thus generating the flow of electrons, as illustrated in Fig. 1(a) [2-7].

DSSCs are made up of layers composed of glass substrates coated with thin films of transparent semiconductor oxides such as FTO (fluor-doped tin oxide) or ITO (indium tin oxide) serving as electrodes, where through certain techniques such as spin coating, drop casting or doctor blade, depositions of TiO_2 (titanium dioxide) made up of nanoparticles are generally carried out in the case of the anode [2-9]. For the cathodic electrode, platinum-based depositions are usually carried out (since it is an inert electrode), and this process is responsible for the catalyzing of electrons (reduction) from the photoanode (oxidizing electrode) [1-3]. The dyes are deposited on the anodic layer, functioning as photosensitizers, interacting with the semiconductor oxides and seeking maximum absorption of the incident solar spectrum. An electrolyte, normally based on iodine (aqueous solution), is deposited between the two electrodes as shown in Fig. 1(b), thus aiding in the transport of electrons [3-8].

To evaluate the photovoltaic parameters of solar cells, such as short circuit current density (J_{SC}), open circuit voltage (V_{OC}), maximum power (Pmax), fill factor (FF) and solar conversion efficiency (η), the

methodology used by the researchers of this group consists of carrying out electrochemical characterizations through a multi-potentiostat (IVIUM Compactstat) coupled to a solar simulator (Ivisun® IVIUM Technologies). The photosensitizers are analyzed through optical characterizations using Fourier transform infrared spectroscopy (FTIR) with the Agilent Cary 630 equipment and ultraviolet visible spectroscopy (UV-vis) with the SHIMADZU UV-2600i spectrophotometer. The roughness of the electrode layers (anode and cathode) is also verified, using the atomic force microscope (AFM) Nanosurf EasyScan 2 and the scanning electron microscope (SEM) JEOL JSM-7100F.

The laboratory has experience in the manufacture of DSSCs using natural dyes as photosensitizers extracted from fruits and flowers since 2014 [4-8], having managed to reach a level of 0.95% solar conversion efficiency so far with the extract of *Malus Domestica* [9], being considered a significant advance for being well above the results found in the literature for this type of device [10]. Future experiments are being performed in searching for new sensitizing dyes, such as *Chrysanthemum* (violet), where the efficiency has been improved to 1.35% for that new techniques has been applied in favor of that purpose.

Keywords: Dye Sensitized Solar Cell, Renewable Energy, Natural Photosensitizers.

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References

[1] O'REGAN, Brian; GRÄTZEL, Michael. A low-cost, high-efficiency solar cell based on dye-sensitized colloidal TiO_2 films. Nature, v. 353, n. 6346, p. 737, 1991. DOI: 10.1038/353737a0.

[2] FERREIRA, F. C. et al. Photoelectric performance evaluation of DSSCs using the dye extracted from different color petals of Leucanthemum vulgare flowers as novel sensitizers. Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy, v. 233, p. 118198, 2020. DOI: 10.1016/j.saa.2020.118198.

[3] FERREIRA, B. C. et al. Influence of nanostructured TiO_2 film thickness in dye-sensitized solar cells using naturally extracted dye from Thunbergia erecta flowers as a photosensitizer. Optical Materials, v. 86, p. 239-246, 2018. DOI: 10.1016/j.optmat.2018.10.016.

[4] SAMPAIO, D. M. et al. Design and characterization of organic solar cells containing nanostructured semiconductor thick films by cost-effective method. Conference: 23rd ABCM International Congress of Mechanical Engineering, 2015. DOI: 10.20906/CPS/COB-2015-0594.

[5] SAMPAIO, Daniel; THIRUMAL, Elumalai; DE BARROS, Ana Lucia Ferreira. Desenvolvimento e Construção de um Sistema de Baixo Custo para Caracterização de Células Solares Sensibilizadas por Corantes Orgânicos. Proceeding Series of the Brazilian Society of Computational and Applied Mathematics, v. 4, n. 1, 2016. DOI: 10.5540/03.2016.004.01.0015.

[6] SAMPAIO, D. M.; THIRUMAL, E.; DE BARROS, A. L. F. The effect of photo-anode surface morphology and gel-polymer electrolyte on dye-sensitized solar cells with natural dyes. Journal of Materials Science: Materials in Electronics, v. 27, n. 9, p. 9953-9961, 2016. DOI: 10.1007/s10854-016-5066-4.

[7] SAMPAIO, D. M. et al. Investigation of nanostructured TiO_2 thin film coatings for DSSCs application using natural dye extracted from jabuticaba fruit as photosensitizers. Ionics, v. 25, n. 6, p. 2893-2902, 2019. DOI: 10.1007/s11581-018-2753-6.

[8] DA CONCEIÇÃO, L. R. B. et al. Passiflora edulis and Cocos nucifera extracts as light-harvesters for efficient dye-sensitized solar cells. In: 2020 IEEE ANDESCON. IEEE, 2020. p. 1-5. DOI: 10.1109/ANDESCON50619.2020.9272107.

[9] DA CONCEIÇÃO, Leonardo Ricardo Bernardes; DE BARROS, Ana Lucia Ferreira. FABRICAÇÃO DE CÉLULAS SOLARES SENSIBILIZADAS POR CORANTES ORGÂNICOS: MALUS DOMESTICA. DOI: 10.5151/siintec2019-30.

[10] BHOGAITA, Mehul; SHUKLA, A. D.; NALINI, R. Pratibha. Recent advances in hybrid solar cells based on natural dye extracts from Indian plant pigment as sensitizers. Solar Energy, v. 137, p. 212-224, 2016. DOI: 10.1016/j.solener.2016.08.003.

Main Changes of the New Regulatory Framework of Distributed Generation in Brazil and Future Prospects

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Abstract

Distributed Generation (DG) provides the installation of small sources of energy generation near or next to the consumer units, both for their own consumption and for the possible transfer of the surplus to the distributor's network. In this context, photovoltaic solar energy has been gaining prominence in the world market for technical, environmental, and economic reasons.

In Brazil solar DG is a highlighted issue, according to [1] between 4,444 Wh/m^2 and 5,483 Wh/m^2 occur daily in the country, which in the last decade has led public policies to regulate and implement a system of incentives for micro and mini distributed generation (MMDG). The National Electric Energy Agency (ANEEL) reported that in june 2022 the country surpassed the mark of 11 GW of installed power for MMDG in consumer units.

In april 2012, Normative Resolution (REN) no. 482 went into effect through the ANEEL. The regulatory framework guaranteed that the active electrical energy produced by a consumer unit would be passed on to the distributor and subsequently compensated in the form of credits, valid for 36 months. In addition, MMDG concepts were defined, described as electric power generating plants that are differentiated by the installed power, being microgeneration less than or equal to 100 kW and minigeneration greater than 100 kW and less equal to 1 MW [3].

In November 2015, there was an update to REN no. 482 with the publication of REN no. 687, through ANEEL, in which the active power limits that delimit microgeneration were reduced to 75 kW and for minigeneration they became greater than 75 kW and less than or equal to 5 MW. As evidenced in [4], these changes allowed new enterprises to be added in order to meet the needs of each of the consumers, being them: remote self-consumption, shared generation, and enterprise with multiple consumer units (EMCU). The validity period of active energy credits was also changed from 36 to 60 months [4].

Posteriorly, Law no. 14,300/2022 [5] was published on January 7, 2022 and came into effect on the same date, it establishes the MMDG legal framework, the Electricity Compensation System and the Social Renewable Energy Program; and assigns other determinations. The way energy credits are valued was largely responsible for the new legal framework of the MMDG, which changed the current full compensation of energy tariff components. The energy tariff is the amount paid by the final consumer, which contains, in addition to the energy sold, all the tariff components of the energy production and transportation process, which pay for the use of the distribution system (wire B) and transmission (wire A), plus other charges and taxes that are intended to fund public policies.

The legislation determined a vacancy period for projects already existing or applied for within 12 months from the date of publication of Law no. 14,300/2022, which will fall under the existing energy compensation rules. This acquired right will be valid until 2045. According to [5], after the vacancy period, a transition rule will be applied with the gradual collection of tariff components related to wire B for: distributed generation at the load, EMUC, shared generation, self-consumption up to 500 kW and dispatchable sources. The exception will be for remote self-consumption projects with power above 500 kW, or for shared generation in which a single owner holds 25% or more of the surplus power share, in

which cases 100% of wire B, 40% of wire A and 100% of the research and development and energy efficiency charges and the electricity services inspection fee will be charged immediately [5].

The new legal framework solved the problem of double billing of the minimum billable consumption, which was being made in credits and in monetary value simultaneously, so the energy injected by DG should no longer be discounted from the availability cost range, reaching this limit the surplus will be converted into credits for the consumer [5]. Moreover, Law no. 14,300/2022 also diversified the ways to perform the distribution of surplus and accumulated credits of a DG, a more flexible regulation was adopted, the holder may transfer credits freely and assign priority order among consumer units for the compensation of the energy tariff.

The scenarios simulated by the Decennial Energy Plan 2031 [6] indicate that if the incentives that already existed before the legal framework were maintained, in the next decade about R$ 168 billion would be invested in MMDG alone. However, as indicated by [7], in the next decades the installation costs of photovoltaic systems will reduce, accompanied by the growth of installed capacity, which justifies the growth projections for MMDG in the coming years.

Therefore, the natural and legal aspects of the country had favored, during the last decade, the accelerated development of DG, consolidating it in the brazilian electricity system. The legal framework for DG, as of the publication of Law no. 14,300/2022, ensures greater legal certainty for DG and regulation regarding the tariff compensation of energy, boosting future prospects of continued growth of DG in the country.

Keywords: Distributed Generation, New Regulatory Framework, Photovoltaic Solar Energy.

References

[1] PEREIRA, E. B.; MARTINS, F. R.; GONÇALVES, A. R.; COSTA, R. S.; LIMA, F. L.; RÜTHER, R.; ABREU, S. L.; TIEPOLO, G. M.; PEREIRA, S. V.; SOUZA, J. G. “Brazilian solar energy atlas.” (in Portuguese), 2.ed. São José dos Campos: INPE, 2017.

[2] ANEEL - Brazilian Electricity Regulatory Agency. Distributed Generation, 2022. [Online]. Available: https://app.powerbi.com/view?r=eyJrIjoiY2VmMmUwN2QtYWFiOS00ZDE3LWI3NDMtZDk0NGI4MGU2NTkxIiwidCI6IjQwZDZmOWI4LWVjYTctNDZhMi05MmQ0LWVhNGU5YzAxNzBlMSIsImMiOjR9. [Accessed: 01-Jun-2022].

[3] ANEEL - Brazilian Electricity Regulatory Agency, “Resolution no. 482.” (in Portuguese), Brasília, 2012.

[4] ANEEL - Brazilian Electricity Regulatory Agency, “Resolution no. 687.” (in Portuguese), Brasília, 2015.

[5] MME - Ministry of Mines and Energy and ME - Ministry of Economy. (2022, Jan. 06). “Law no. 14300/2022.” (in Portuguese), Brasília, 2022.

[6] MME - Ministry of Mines and Energy and EPE - Energy Research Company, “2031 Decennial Energy Expansion Plan.” (in Portuguese), Brasília, 2022.

[7] IEA - International Energy Agency. "Energy technology perspectives 2012". Technical report. Organization for Economic Cooperation & Development, Paris, 2012.

Practical Effect of Time on Solar Energy Generation Based on Thermoelectric Effect

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Abstract

The society is waking up to the consequences of fossil fuel use and its harmful effects on the environment and human health. As a consequence, international entities, as The United Nations (UN) have been expressing their concern with the energy generation's future on our planet, mobilizing world leaders with aim of drastically reducing the pollutants gases effects and increasing the use alternative energies [1].

In this context, Alternative Energies are implemented in the energy matrix, not only as an auxiliary source but as the energy generation's future. For example, the sun provides the Earth daily with an amount of energy that, if used properly, would have the capacity to supply all the daily energy consumption of the planet several times over [2]. Thus, the energy that comes from the sunlight and heat can be used to generate electricity reducing the consumption of other non-renewable energy sources.

In this project, the direct use of solar radiation is highlighted and its direct conversion into electrical energy through Peltier-Seeback thermoelectric effect. In addition, the perception of how the position of the sun and the time of day influence the level of voltage generated was analysed. For this, it was necessary to study some concepts, such as: thermoelectricity and the effects that establish the correlation between thermal energy and electricity (Seebeck, Peltier and Thomson effects) [3]. In general, the Peltier-Seebeck effect stands out, which are two effects that can be considered as one because they are different manifestations of the same physical phenomenon.

In order to explore the capture of the sun's rays more efficiently, a pyramidal structure with reflective material was developed (shown in Fig. 1). The design used allows the solar rays to fall on the inner side walls of the truncated pyramid. Then they are reflected downwards, creating a focus zone to increase the temperature at the bottom of the pyramid.

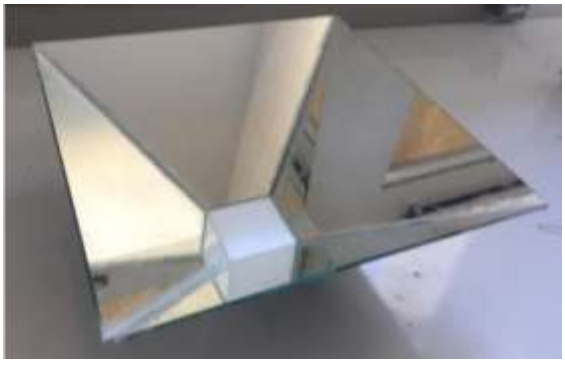

Figure 1 - Pyramidal solar capture device

Thermoelectric modules, called Peltier modules TEC1-127063, were placed in the focus zone of the sun's rays. These modules consist of a union of two sheets of insulating material, with an inner mesh of conductive material on the inner surfaces of the sheets, where the thermocouples are located - which are responsible for transforming thermal energy into electrical energy or the opposite [4]. The tests to verify the practical effects of the hours of a day and the sun's position for the generation of solar energy were

carried out, mainly in the peak hours of the sun, with four modules connected in parallel and the voltage generated was measured with a multimeter. In Fig. 2 is shown the graph of max RMS voltage generated in an interval of 1.4 hs.

Figure 2 - Electrical voltage generation by hours

From these results, it was possible to conclude that with the approach of the peak hour, in this case 12:25 p.m., the voltage generate increased, in the same way that when passing this time, the voltage begins to decrease. In addition, it was also possible to observe that they had some peaks downwards, being in these cases moments when the clouds passed in front of the sun, interrupting the solar rays from reaching the Peltier modules. Therefore, the results obtained are significant, with the possibility of being optimized and improved. It is demonstrate in a satisfactory way the effect of the passing of the hours and the change of the position of the sun in the generation of thermoelectric energy from the solar capture. It is noteworthy that between 12:25 and 12:52 p.m. is the interval in which there is the highest average level of voltage generation.

Keywords: Solar Capture, Thermoelectric effects, Energy generation, Thermoelectric modules.

References

[1] UN: UNITED NATIONS. UN Climate Change Annual Report. UNFCCC: United Nations Framework Convention on Climate Change.,pp. 10-14, 24 Dec. 2018, [Online]. Available: https://unfccc.int/sites/default/files/resource/UN-Climate-Change-Annual-Report-2018.

[2] C. T. Machado and F. S. Miranda, "Energia Solar Fotovoltaica: Uma Breve Revisão," Revista Virtual de Química, vol. 7, no. 1, pp. 126–143, 2015, [Online]. Available: https://rvq-sub.sbq.org.br/index.php/rvq/article/view/664/508.

[3] J. dos R. Borges, "O efeito Seebeck aplicado na termometria," pantheon.ufrj.br, May 2012, Accessed: Jun. 09, 2022. [Online]. Available: https://pantheon.ufrj.br/handle/11422/8033.

[4] A. Junior and O. Hideo, "Protótipo de um microgerador termoelétrico para captação de energias residuais baseado no Efeito Seebeck com sistema de transferência de calor intercambiável," 2014, [Online]. Available: https://www.lume.ufrgs.br/handle/10183/103721.

Environmental Impacts by Outdoor Activities in Northern Portugal

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Abstract

In recent years, tourism in natural and outdoor areas has grown significantly [1] and the tourism concentration in the territories can cause impacts. Outdoor tourism can be understood as the activities practised in natural protected areas, in rural areas or in urban parks [2].

Given the characteristics associated with tourism activities, these cause impacts on destinations, which can be positive or negative, whether economic, socio-cultural, or environmental. In this study, we focused on environmental impacts, mainly due to the characteristics of outdoor activities. Tourism's main positive environmental impacts are the preservation of natural areas, the improvement of infrastructure and the planning of natural areas to adapt them for tourism use [3]. More prevalent are the negative environmental impacts, which can be visual and noise pollution, air and water pollution, waste dumping in natural environments, deforestation, wildlife disturbance, loss of biodiversity, congestion, compaction, erosion and decline in soil fertility [4]. The great concentration of people at a destination, leaving waste and not concerning themselves with the environment, can affect the vegetation cover, the beauty of the landscape, and the ecosystem in general [5]. Moreover, the same can be observed in rivers and oceans, where a large number of plastics and other kinds of waste are found, affecting fauna in particular.

Important to highlight that this list of impacts will always be incomplete due to the diversity of effects caused by the activity on the environment, for such reason, the constant monitoring of the activities is necessary [4]. Some of the most used tools in the tourism area are Environmental Impact Assessment (EIA) [6], and Tourism Impact Assessment (TIA) [4].

To understand the profile of practitioners of outdoor activities and the possible impacts of this activity in Northern Portugal, a survey was run with 216 participants from July to September 2021. Outdoor activities were split into the land-based, aquatic, and aerial categories. Based on descriptive statistics was possible to determine the frequency of practising these activities. Considering the previous studies on impacts, the types of the environmental impacts caused by each of the categories of activities were determined, and some suggestions were delimited to maximise the positive impacts and minimise the negative impacts, ensuring the region's sustainability.

The sample is constituted of women (50.5%), aged between 28-38 or over (58.5%), with higher education levels (70.5%), single (53.3%) and Portuguese (94.5%), with an average monthly income between 601€ and 2400€ (74%). Most of them live in the Porto Metropolitan Area (25%). Relating to outdoor activities, 35.5% of the sample occasionally practise these activities in their residence area, and 20% practise 1-2 times a week. The activities most practised were walking/hiking (28.8%), running (11.7%), and cycling (9.5%).

Considering the negative environmental impacts presented by Canteiro et al. [4], the most practised outdoor activities in the North of Portugal were divided into the three categories previously presented and then determined the respective negative impacts caused (Table 1).

Regarding the positive environmental impacts, all the mentioned activities can help in the preservation of natural areas, infrastructure improvements and in the planning of natural areas to adapt them to tourism use.

Understanding the tourism impacts can improve the planning and managing of outdoor tourism. It is also necessary to consider climate change concerns in this planning and monitoring process. Some of the tools cited in this study can be suitable for the Portuguese reality and used for this monitoring. A suggestion is the use of EIA for impact assessment.

Table 1 - Outdoor Activities practised in North of Portugal

Classification		Activities	%	Negative Environmental Impacts
Land-based		Circuits/tourist routes; Climbing; Mountain biking; Walking/hiking; Cycling; Paintball; Hunting; Trails; Running; Trekking; Sports; Trail running; Paddle.	72.9	- Habitat reduction; - Compaction and erosion of soil; - Pollution; - Perturbation (e.g., people can perturb animals).
Aquatic		Surfing; Rafting; Canyoning; Canoeing; Nautical activities in general.	21.1	- Habitat reduction; - Pollution of water; - Perturbation (e.g., motorised water vehicles can perturb aquatic animals).
Aerial		Slide; Paragliding.	6.0	- Air pollution.

Source: Authors' elaboration.

Another action is promoting tourists' awareness of the need for environmental preservation. In this way, information campaigns can be carried out focusing on some criteria such as keeping the sites exactly as they were found, avoiding leaving waste, not feeding wild animals, conserving vegetation, and not removing anything from its place of origin.

Finally, assessment and sensitisation are essential to minimise negative environmental impacts, minimise the impacts of climate change and ensure the sustainability of the territories in the North of Portugal.

Keywords: Environmental Impacts, Outdoor Tourism, Sustainability.

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References

[1] F. A. Ferreira, E. Costa, J. Ribeiro, and A. Reis, "Perceptions of Covid-19's impact on outdoor tourism in the Peneda-Gerês National Park," *J. Tour. Dev.*, vol. 1, no. 36, pp. 393–408, 2021, doi: 10.34624/rtd.v1i36.23748.

[2] M. Derek, E. Woźniak, and S. Kulczyk, "Clustering nature-based tourists by activity. Social, economic and spatial dimensions," *Tour. Manag.*, vol. 75, no. March, pp. 509–521, 2019, doi: 10.1016/j.tourman.2019.06.014.

[3] E. C. B. Scalabrini and P. C. Remoaldo, "Residents' perception towards tourism in an industrial Brazilian city: A cluster analysis," *Rev. Bras. Gest. e Desenvolv. Reg.*, vol. 16, no. 1, pp. 235–247, 2020.

[4] M. Canteiro, F. Córdova-Tapia, and A. Brazeiro, "Tourism impact assessment: A tool to evaluate the environmental impacts of touristic activities in Natural Protected Areas," *Tour. Manag. Perspect.*, vol. 28, no. November 2017, pp. 220–227, 2018, doi: 10.1016/j.tmp.2018.09.007.

[5] E. M. Maldonado-Oré and M. Custodio, "Visitor environmental impact on protected natural areas: An evaluation of the Huaytapallana Regional Conservation Area in Peru," *J. Outdoor Recreat. Tour.*, vol. 31, 2020, doi: 10.1016/j.jort.2020.100298.

[6] J. Pope, J. A. Wessels, A. Douglas, M. Hughes, and A. Morrison-Saunders, "The potential contribution of environmental impact assessment (EIA) to responsible tourism: The case of the Kruger National Park," *Tour. Manag. Perspect.*, vol. 32, no. July, p. 100557, 2019, doi: 10.1016/j.tmp.2019.100557.

Municipal Solid Waste Biorefineries: A State-of-the-Art

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Abstract

The acceleration of global industrialization, the constant growth of the population and the concern with carbon emissions, generates the need to create alternative solutions to guarantee not only the energy demand, but also to improve Municipal Solid Waste (MSW) management [1-3].

MSW is a residual resource that requires immediate attention and effective management techniques. Two of the United Nations Sustainable Development Goals (SDGs), Goal 12 (Responsible Consumption and Production) and Goal 11 (Sustainable Cities and Communities) address this issue. Moreover, an additional goal (Goal 7: Clean and Affordable Energy) can also be achieved if MSW is converted into biomass for bioenergy generation [3], [4]. MSW biorefineries are a technically, economically, and environmentally effective approach to sustainable development [3-5].

Thus, this paper aims to analyze the state-of-the-art of Municipal Solid Waste (MSW) biorefineries through bibliometric and systematic literature reviews. The main objective is to identify MSW valorization technologies and how biorefineries can contribute to this process. For this, the current production and management of MSW will also be presented.

The analysis performed was based on documents found in the Web of Science database published in the last ten years and in English. The keywords used were "municipal solid waste" AND "biorefinery". From the set of keywords used, 239 documents were found. Of these, 60 were review articles, and these were selected to compose the theoretical framework of this paper.

Among the main countries publishing on the subject are: Italy (40 articles), China (35 articles), and India and the USA, both with 25 articles. In addition, it is possible to observe an exponential growth of publications on the topic, where the year 2020 (49 publications), for example, had a growth of almost 100% of publications compared to the period 2018 (25 publications). Confirming the trend pointed out by several authors that a worldwide interest in exploring MSW streams as renewable energy sources, and highlighting bioenergy and biofuels as the core energy technologies deployed in the European Union to meet the targets of the Renewable Energy Directive [1-6].

On a global scale, municipal solid waste is mostly disposed of in landfills (controlled or not) or dumped. Only a small portion is subject to recycling (13%), composting (5%) or incineration (11%) [7-8]. Other valorization techniques represent only 1% [9]. The MSW recovery techniques present in the literature are waste-to-energy technologies, the main ones being: anaerobic digestion, composting, incineration, and gasification, but fermentation, hydrogen production, carbonization, and pyrolysis techniques also appear. The term "biorefineries" appears through the association of two or more waste-to-energy technologies, where the main related methodologies are Life Cycle Analysis (LCA) and economic analysis. Despites that, emerging technologies like photofermentation, dark fermentation and CO_2 capture techniques are still not related to the topic. In addition, the term "Circular Economy" also show up related to the search.

In conclusion, it is possible to identify the emerging need for the Municipal Solid Waste to be seen as a resource, thus being able to serve as biomass for the production of biofuels and value-added bioproducts. Moreover, the association of biorefineries with MSW is a complete alternative, where all fractions of the raw material can be properly valued and/or treated, generating the optimization of the use of the potential energy of the waste and

reducing the impacts associated with its deposition.

The main contribution of this paper is to identify the potential of combining common technologies, such as anaerobic digestion, and emerging technologies, such as CO_2 capture through microalgae, should be more widely explored. These can be part of the configuration of integrated MSW biorefineries and actively participate in the energy transition and decarbonization.

For future studies, the feasibility study of a MSW biorefinery is proposed, where the technical, economic and environmental aspects are discussed.

Keywords: Municipal Solid Waste, Biorefinery, Systematic Review, Bibliometric Review.

References

[1] S. Satchatippavarn, E. Martinez-Hernandez, M. Y. Leung Pah Hang, M. Leach, and A. Yang, "Urban biorefinery for waste processing," *Chemical Engineering Research and Design*, vol. 107, pp. 81–90, 2016, doi: 10.1016/j.cherd.2015.09.022.

[2] S. Nanda and F. Berruti, "A technical review of bioenergy and resource recovery from municipal solid waste," *Journal of Hazardous Materials*, vol. 403, no. September 2020, p. 123970, 2021, doi: 10.1016/j.jhazmat.2020.123970.A. Taflove, *Computational Electrodynamics: The Finite-Difference Time-Domain Method* in Computational Electrodynamics II, vol. 3, 2nd ed. Norwood, MA, USA: Artech House, 1996.

[3] E. R. A. da Coordenador. SILVA, "Agenda 2030: ODS - Metas Nacionais dos Objetivos de Desenvolvimento Sustentável," p. 546, 2018, [Online]. Available: http://repositorio.ipea.gov.br/handle/11058/8855%0Ahttps://www.ipea.gov.br/portal/index.php?option=com_content&id=33895

[4] S. Varjani *et al.*, "Sustainable management of municipal solid waste through waste-to-energy technologies," *Bioresource Technology*, vol. 355, p. 127247, Jul. 2022, doi: 10.1016/j.biortech.2022.127247.

[5] Y. Duan, A. Pandey, Z. Zhang, M. K. Awasthi, S. K. Bhatia, and M. J. Taherzadeh, "Organic solid waste biorefinery: Sustainable strategy for emerging circular bioeconomy in China," *Industrial Crops and Products*, vol. 153, no. March, p. 112568, 2020, doi: 10.1016/j.indcrop.2020.112568.

[6] A. Kumar and S. R. Samadder, "A review on technological options of waste to energy for effective management of municipal solid waste," *Waste Management*, vol. 69, pp. 407–422, 2017, doi: 10.1016/j.wasman.2017.08.046.

[7] S. Kasa, L. Yoa, P. Bhada-Tata, and F. van Woerden, *What a WASTE 2.0: A Global Snapshot of Solid Waste Management to 2050*. World Bank Group, 2018. doi: 10.1596/978-1-4648-1329-0.

[8] K. D. Sharma and S. Jain, "Municipal solid waste generation, composition, and management: the global scenario," *Social Responsibility Journal*, vol. 16, no. 6, pp. 917–948, 2020, doi: 10.1108/SRJ-06-2019-0210.

[9] N. Kundariya *et al.*, "A review on integrated approaches for municipal solid waste for environmental and economical relevance: Monitoring tools, technologies, and strategic innovations," *Bioresource Technology*, vol. 342, no. May, p. 125982, 2021, doi: 10.1016/j.biortech.2021.125982.

Wind Turbine Blade Waste: A Quantifying Model

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Abstract

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

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

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

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

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

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

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

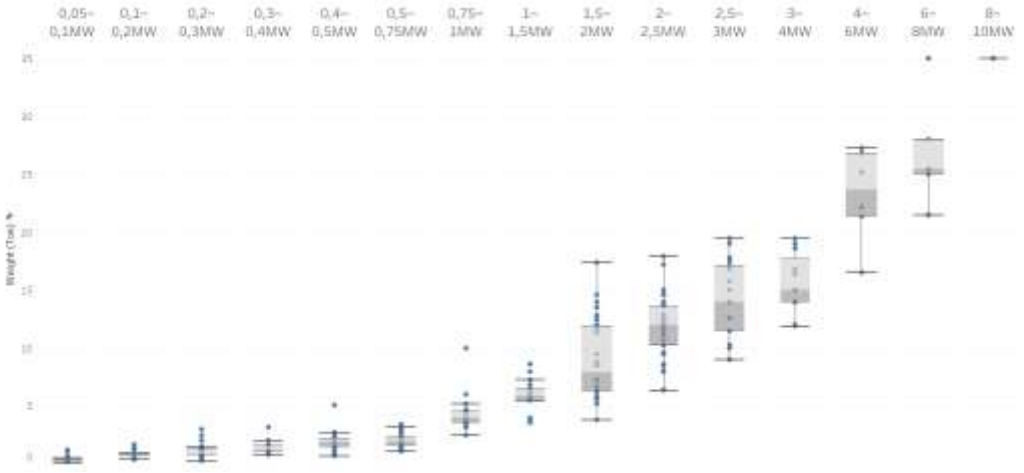

Figure 1 - Weight distribution by rated power

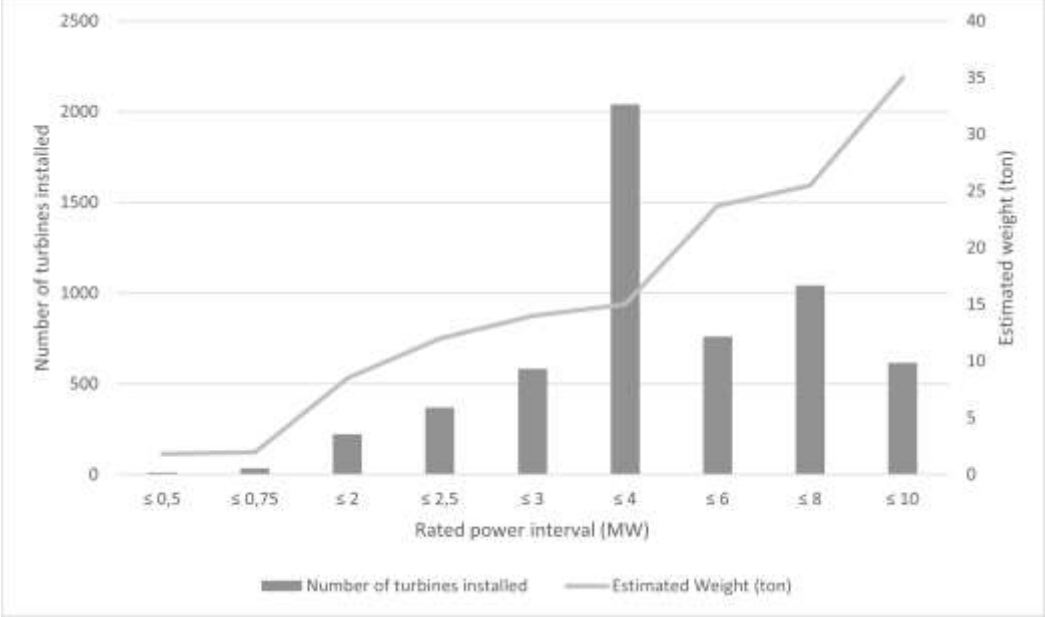

Figure 2 - Estimated weight of offshore turbines in Europe

Keywords: Wind turbine blade, waste, model.

References

[1] GWEC – Global Wind Energy Council. Global wind report – annual market update 2014. (2014). pp. 45.

[2] European Commission. Towards net-zero emissions in the EU energy system by 2050. (2020).

[3] Beauson, J., Bech, J. I., Brøndsted, P. (2014). Composite recycling: Characterising end of life wind turbine blade material. In Proceedings of 19th International Conference on Composite Materials.

[4] Bauer, L. and Matysik S. (2022). Wind-Turbine-Models. Available at <https://en.wind-turbine-models.com/>. Accessed on 22 June 2022.

[5] Wind Europe. European Offshore Wind Farms Map Public. Available at < https://windeurope.org/intelligence-platform/product/european-offshore-wind-farms-map-public/>, Accessed on 25 June 2022.

Numerical Investigation of Contaminant Distribution in a Room

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Abstract

Indoor air quality maintenance is an important task for the preservation of the health of the occupants of indoor spaces [1]. If there is human exposure to contaminants, it is necessary to implement means of removing the contaminant, providing a healthy environment. One of the main ways to maintain indoor air quality is the use of ventilation systems, which aids in the speed of contaminants removal [2].

The study of aerodynamics circulation helps in understanding air renewal time [3]. Furthermore, in applications involving healthcare (such as to remove contaminants), knowledge of air distribution patterns are important, thus avoiding stratified air zones [4]. The use of numerical simulation is paramount to obtain detailed data and can be used to complement experimental measurements [5, 6, 7].

The present work aimed at comparing different methods for computational simulation, for the analysis of indoor air quality. The Fire Dynamics Simulator (FDS), CONTAM and the Eulerian box model (EBM) were used for this purpose. The results were compared with experimental data available in the literature [5]. The main contribution of the present work is to evaluate the potential of several options for computational simulation in obtaining results for ventilation systems design.

The geometry proposed for study was originally presented and widely discussed by [5]. The environment has dimensions of 4.00x2.50x3.00 m, considering the x, y and z axes. Two openings with 0.40x0.40 m are positioned in the z-y planes at x=0 and x=4.00 m. At x=0, the opening is centered and 0.4 m from the surface, while at x=4.0 m the opening is centered and 1.7 m from the surface. At time zero (initial time), the environment has a concentration of 2000 ppm of CO_2. The air velocity at the inlet opening is 1.36 m/s (inlet air flow of 783.4 m^3/h) and has a concentration of 350 ppm of CO_2. The temperature of the inlet and ambient air is 300K. The surfaces of the studied environment are adiabatic and the outgoing air mass is the same as the incoming air mass (mass conservation law).

The solution of the indicated case occurred through the transient solution, where the simulation time was set at 1200 seconds, with data extraction every 100 seconds, from the initial moment to the final moment. The results obtained sought to identify the average concentrations of the contaminant in the environment. For comparative purposes between the different methods, the relative error was estimated from equation (1).

$$Error = \left|\frac{C.R.-E.R.}{E.R.}\right| \times 100 \quad (1)$$

where C.R. is the computational result and E.R. is the experimental result. Through the relative error it is possible to evaluate which methodology presents the best results. The main results are shown in Table 1.

Table 1 - Average error results of the evaluated computational simulations.

Computational Method	CONTAM	FDS	EBM
Average Error (%)	5.2	6.9	4.9

The average error for CONTAM was 5.2%, for the FDS it was 6.9% and for the EBM it was 4.9%. The biggest difference in the results is reported at the beginning of the time, which indicates the difficulty of the models in identifying the dispersion of the contaminant in the environment. In the first 200 seconds, the relative error

presented by the FDS was 25%, while for the other methods the relative error was in the range of 3.7% and 4%, considering the EBM and CONTAM, respectively. The CONTAM software, as well as the EBM, considers a homogeneous mixture of the contaminant in the environment, thus having similar errors. The FDS solves the flow fields in greater detail, which may lead to a different solution according to the turbulence model applied. Taking into account all results, it is indicated that after 800 seconds there is a total renewal of the ambient air. The solution through the CONTAM software and the EBM requires less computational effort, providing faster results than the solution obtained through the FDS. Thus, for the proposed case, there is a greater difficulty of the FDS in the initial seconds of the simulation, when the turbulence-mixing rate occurs due to the transient characteristic of the studied case.

Considering the obtained results, through the comparison between experimental and numerical data, it is possible to indicate the good capacity of the computational solution in obtaining data regarding air renewal or removal of contaminants. The possibilities of using computer simulation can complement the monitoring of the environment through sensors. The previous design of ventilation systems through computer models is a possibility of use, thus anticipating the needs of the environment.

Keywords: Indoor Air Quality, Computational Solution, FDS, CONTAM, Eulerian Box Model.

References

[1] S.E. Kwan, R. Shaughnewwy, U. Haverinen-Shaughnessy, T.A. Kwan, J. Peccia, "The impact of Ventilation Rate on the Fungal and Bacterial Ecology of Home Indoor Air", Building and Environment, v. 177, 2020.

[2] J. González-Martín, N.J.R. Kraakman, C. Pérez, R. Lebrero, R. Moñoz, "A state-of-the-art review on indoor air pollution and Strategies for Indoor Air Pollution Control", Chemosphere, v. 262, 2021.

[3] S. Gilani, H. Montazeri, B. Blocken, "CFD Simulation of Stratified Indoor Environment in Displacement Ventilation: Validation and Sensitivity Analysis", Building and Environment, v. 95, pp. 299-313, 2016.

[4] X. Tian, Y. Cheng, J. Liu, Z. Lin, "Evaluation of Sidewall Air Supply with the Stratified Indoor Environment in a Sunsultation Room", Sustainable Cities and Society, v.75, 2021.

[5] K-C Chung and S-P. Hsu, "Effect of Ventilation Pattern on Room Air and Contaminant Distribution", Building and Environment, v. 36, pp. 989-998, 2001.

[6] L. Koufi, Z. Younsi, Y. Cherif, H. Naji, "Numerical Investigation and Analysis of Indoor Air Quality in a Room Based on Impinging Jet Ventilation", Energy Procedia, v. 139, pp. 710-717, 2017.

[7] X. Sui, Z. Tian, H. Liu, H. Chen, D. Wang, "Field Measurements on Indoor Air Quality of a Residential Building in Xi'an Under Different Ventilation Modes in Winter", Journal of Building Engineering, v. 42, 2021.

Becoming Acquainted with Green Roofs Contribution Towards Circular and Resilient Cities

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Abstract

Cities, due to their high population density, are characterized by a high built-up area, extensive soil sealing, and low vegetation cover. In urban areas water is generally exploited in a linear process: "extract from adjacent freshwater ecosystems - use - dispose". Stormwater management aims to discharge rainwater quickly to avoid flooding. However, when rainfall exceeds the capacity of drainage systems, widespread flooding eventually occurs in urban spaces. On the other hand, when dry weather persists, there is a need to watering green spaces in order to maintain them. In this case, water is again used in a linear fashion: drinking water is often used since there are no other water sources that can be considered (1). The impossibility of circular water management in urban areas makes these spaces particularly vulnerable to extreme droughts and floods, which in a climate change scenario are increasingly frequent. It is therefore urgent to increase the resilience of cities by promoting measures to make cities "Water Wise Cities" (2). The implementation of green infrastructures as a complement to grey infrastructures is crucial to achieve this goal. These green infrastructures include Nature-Based Solutions (NBS) that provide various environmental services (e.g. water, soil, and biodiversity conservation, making cities more resilient to climate change) and socio-economic services (e.g. creating places to live, jobs, property valuation).

Green roofs are an example of NBS that can be used in conjunction with other tools aimed at promoting the circular economy of water in urban spaces. These structures are built based on technical and scientific guidelines and result from planting vegetation on a substrate followed by several layers of other materials that sit on a built structure (3). Green roofs can be constructed at ground level or on top of buildings and are efficient solutions to mitigate flooding as they delay the peak flow of stormwater, releasing the water gradually (sponge effect) and avoiding overloading the stormwater drainage system. Part of this water infiltrates and is retained in the substrates, being released during dry periods by evapotranspiration (4). In addition to being important tools for circular urban water management, these structures also offer potential benefits in terms of aesthetic value, biodiversity conservation, noise, air pollution, and "heat island" effect reduction, ultimately promoting energy efficiency and the reduction of CO_2, and other greenhouse gas emissions.

However, although the widespread implementation of green infrastructure in urban spaces is foreseen in European (e.g. European Green Deal) and global (e.g. Sustainable Development Goals - United Nations Agenda 2030) policies and strategies, there are still difficulties for large-scale implementation. These difficulties are in part due to the fact that the concept of green infrastructure is relatively new and complex, nor sufficient quantitative analysis and indicators. As a result, it is very difficult for policy makers to integrate it into various policies. On the other hand, there is still a widespread lack of knowledge by the public and private sectors, as well as the general public, of the high potential contribution of this natural engineering tool for water and energy management in urban areas, which, together with the need for the intervention of professionals from different disciplines, hinders a greater implementation of these infrastructures in urban areas.

Therefore, the aims of the present communication are:

1) Presenting the project "Exploring the functioning and functions of green roofs in water management:

A prototype for experimental and interactive activities", winner of the 1st prize in the environment category of the ideas contest “Ideias Hidrodinâmic@s” promoted by Ciência Viva, Fundação Calouste Gulbenkian, and Águas do Tejo Atlântico, that will be implemented in IPB;

2) Discussing the state of the art of green roofs in Portugal;
3) Introducing some approaches on green roofs that are being developed by the team, namely in Master’s degree theses.

Keywords: Green Roofs, Urban Water Management, Circular Economy, Nature-Based Solutions

References

[1] D. Pearlmutter et al., «Closing Water Cycles in the Built Environment through Nature-Based Solutions: The Contribution of Vertical Greening Systems and Green Roofs», Water, vol. 13, n. 16, Art. n. 16, jan. 2021, doi: 10.3390/w13162165.

[2] «The IWA Principles for Water Wise Cities», International Water Association. https://iwa-network.org/publications/the-iwa-principles-for-water-wise-cities/ (acedido 7 June 2022).

[3] C. S. C. Calheiros, B. Castiglione, e P. Palha, «Chapter 14 - Nature-based solutions for socially and environmentally responsible new cities: The contribution of green roofs», em *Circular Economy and Sustainability*, A. Stefanakis e I. Nikolaou, Eds. Elsevier, 2022, pp. 235–255. doi: 10.1016/B978-0-12-821664-4.00015-7.

[4] C. S. C. Calheiros e A. I. Stefanakis, «Green Roofs Towards Circular and Resilient Cities», Circ.Econ.Sust., vol. 1, n. 1, pp. 395–411, jun. 2021, doi: 10.1007/s43615-021-00033-0.

Environmental Assessment of an Urban Wastewater Treatment Plant by Calculating the Carbon Footprint

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Abstract

Wastewater Treatment Plants (WWTPs) are responsible for reducing the polluting potential of wastewater and, in this way, they are seen as infrastructure that benefits the environment. However, the treatment units convert constituents of the wastewater into non-negligible amounts of greenhouse gases (GHG), causing changes in air quality and contributing to climate change. The main GHGs associated with the emissions from WWTPs are CO_2, CH_4, and N_2O, which are also emitted in greater quantities by human activity[1].

This study aimed at evaluating the carbon footprint associated with the operation phase of a (WWTP), located in the north of Portugal, adopting a methodological approach of Life Cycle Assessment (LCA)[2]. In addition, in order to propose a set of measures leading to the reduction of GHG emissions from the WWTP under study, a set of alternative scenarios was also assessed.

After defining the objectives and the scope of the study, an inventory form was prepared to collected all necessary data and information directly from the WWTP managers, as well as from a set of other available information sources. The inventory was organized with basis on the methodology adopted by the Intergovernmental Panel on Climate Change, which separates the contribution of emissions by 3 different categories - direct, indirect internal and indirect external emissions [3]. The inventory was also carried out for a set of alternative scenarios related to changes in the treatment process, implementation of renewable energy and management of sludge produced at the WWTP. The carbon footprint was then estimated for all situations using an excel tool, adapted from the computer application "Calculating the carbon footprint of Swedish wastewater treatment plants" (SVU 12-120).

The basic equations used in the calculation of the GHG emissions are presented below [4]:

$$CO_2 = 10^{-6} * Q_{ww} * CBO_5 * Eff_{CBO5} * CF_{CO2} * [(1 - MCF_{ww} * BG_{CH4})(1 - \lambda)] \quad (1)$$

$$CH_4 = 10^{-6} * Q_{ww} * CBO_5 * Eff_{CBO5} * CF_{CH_4} * \left[\left(MCF_{ww} * BG_{CH_4}\right)(1 - \lambda)\right] \quad (2)$$

$$N_2O = Qi * TKNi * EF_{N_2O} * \frac{44}{28} * 10^{-6} \quad (3)$$

The main results are shown in Figure 1 and Figure 2. Figure 1 shows the total carbon footprint separated into direct and indirect emission sources.

Figure 2 presents the possible reductions resulting from the implementation of some changes.

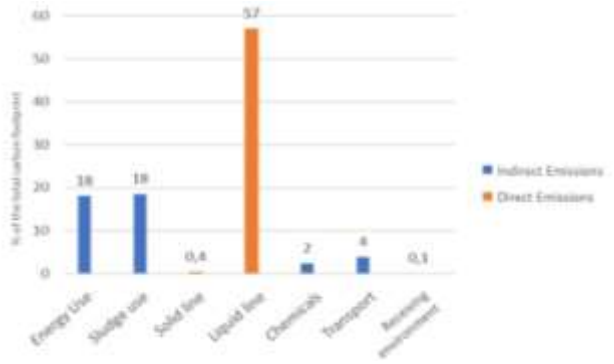

Figure 1 - Relative contribution of each process of the study system to the carbon footprint.

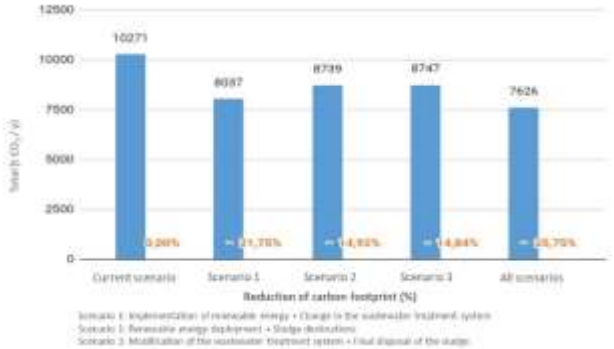

Figure 2- Total annual CO_{2e} emission and carbon footprint reduction for each process of the study system, after implementation of some alternative scenarios.

In general, the carbon footprint obtained was 1.3 kg CO_{2e}/m^3 of treated wastewater. The results show that the biological processes of treatment of the WWTP liquid phase constitute the most relevant direct source of GHG, followed by indirect sources related to the use of energy and sludge management. The evaluation of the studied scenarios allowed to obtain footprint reductions of up to 26%, motivated mainly by the implementation of renewable energies and by the change in the treatment of wastewater.

Keywords: GHG; Equivalent carbon dioxide; Methane; Nitrous oxide; Environmental impacts; Climate change.

References

[1] Intergovernmental Panel on Climate Change, Ed., "Chapter 8 - Anthropogenic and Natural Radiative Forcing," in Climate Change 2013 – The Physical Science Basis Working Group I Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, vol. 9781107057, Cambridge: Cambridge University Press, 2013, pp. 659–740.

[2] NP EN ISO 14040, "Environmental management - Life cycle assessment - Principles and framework," vol. 2005, no. Idi. p. 29, 2008.

[3] V. Parravicini, K. Svardal, and J. Krampe, "Greenhouse Gas Emissions from Wastewater Treatment Plants," Energy Procedia, vol. 97, pp. 246–253, 2016, doi: 10.1016/j.egypro.2016.10.067.

[4] EPA, "Greenhouse Gas Emissions Estimation Methodologies for Biogenic Emissions from Selected Source Categories : Solid Waste Disposal Wastewater Treatment Ethanol Fermentation," US Environ. Prot. Agency, no. 0210426, pp. 1–43, 2010, [Online]. Available: https://www3.epa.gov/ttnchie1/efpac/ghg/GHG_Biogenic_Report_draft_Dec1410.pdf.

An Analysis of the Relationship Between Working from Home and Environmental Impacts

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Abstract

The Covid-19 pandemic has been changing the lifestyle, changing routine activities, such as no need to go to the office every day, and avoiding spending time on public transportation. Due to the restrictive measures, companies have decided to implement the working from home system, allowing the activities could continue. This measure can be directly related to some environmental impacts, either by reducing the use of fossil fuels when people travel or by spending more time at home, increasing their consumption of electricity, water, and industrialized products, for example. The debate was presented when we observed data from the "Instituto de Pesquisa Econômica Aplicada (IPEA)" [1] which shows about 11% of Brazilian workers migrated to work from home, corresponding to 8.2 million people working from home. This significant number of workers, each in their own homes, can generate significant impacts on the environment, whether positive or negative. Furthermore, the results of the research show that the geographic issue directly influences these data, since an increase in electricity consumption of 20% to 30% was observed in some regions of the United States, while in the United Kingdom this consumption increased by 15% days after the beginning of the blockade [2]. In Brazil, it was seen that in the first half of 2020, there was a significant reduction in CO_2 emissions in the electricity sector (19%), resulting from the reduction in consumption in the commercial (9.6%) and industrial (5.6%) classes, with a small increase in the residential class (0.3%) [3]. In the Brazilian transport sector, there was a reduction of 11% [3], in the emission of CO_2, due to the restrictions imposed on the population. Additionally, data show that the impact on the generation and solid urban waste increased significantly, increasing 13.4% between 2019 and 2020 [4] [5]. Due to these regional differences, the research adopts the descriptive approach concerning the main reflections that work from home has caused to the environment, intending to propose suggestions to mitigate the negative impacts, toward making outline goals possible in the Paris Agreement [6]. Finally, the research was conducted to generate hypotheses to be analyzed in future research, due to the uncertainty of the impacts caused by work from home, which may be perceived in the coming years. Regardless of the full return of the activities, it has been seen that the impacts of remote work are results of the lifestyle and consumption habits of these workers, and it is up to the companies to create measures that reduce the impacts of this activity, encouraging the control of consumption, either by the energy efficiency of new environments or the reduction of solid waste of daily consumption.

Keywords: Work from Home, Environmental Impacts, Consumption Reduction.

References

[1] IPEA – Institute of Applied Economic Research. Remote work in Brazil in 2020 under the Covid-19 pandemic. Who, how many, and where they are? Available: https://www.ipea.gov.br/portal/images/stories/PDFs/conjuntura/210714_nota_trabalho_remoto.

[2] The Guardian. Is remote working better for the environment? Not necessarily [online]. Available: https://www.theguardian.com/environment/2021/aug/02/is-remote-working-better-for-the-environment-not-necessarily.

[3] IEA - International Energy Agency. Working from home can save energy and reduce emissions. But how much? [on line]. Available: https://www.ies.org/commentaries/working-from-home-can-save-energy-and-reduce-emissions-but-how-much.

[4] ABRELPE – Brazilian Association of Public Cleaning and Special Waste Companies. Overview of solid waste in Brazil, 2020. Available: https://abrelpe.org.br/panorama-2020.

[5] ABRELPE – Brazilian Association of Public Cleaning and Special Waste Companies. Overview of solid waste in Brazil, 2021. Available: https://abrelpe.org.br/panorama-2021.

[6] UNFCCC. United Nations Convention to Combat Desertification. Adoption of the Paris Agreement. FCCC/CP/2015/L.9/Rev.1.

Urban Green Space Conservation: An Approach Within the Scope of Environmental Education

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Abstract

Green areas are spaces studied by several areas of science, such as environmental education, which has an auxiliary aspect in the study of these areas, to preserve them. Thus, this branch of study is of great importance to society, to understand the chemical processes existing in nature, and thus, generate clarification on environmental changes in the absence of these areas and raise awareness of their conservation.

Through studies carried out, we seek to discover new methods to increase the quality of life in urban spaces, as it is known that they are essential for maintaining a balanced environment. In view of this, the following research question arises: How can awareness about the creation and conservation of urban green areas be worked as part of Environmental Education in high schools in the cities of Araguanã and Zé Doca?

Awareness in the school environment about the creation and conservation of urban green areas can be effective, so the research aims to: identify the current ecological landscape of local urban green areas from the perspective of research participants; sensitize local communities to the creation and conservation of urban green areas, through didactic sessions aimed at high school education in these cities; to evaluate the contribution of the didactic proposal to the awareness of the research participants.

Green areas have been reduced over time, this reduction is strongly associated with imbalances in the environment and the growth of cities, directly altering the fauna, “the lack of afforestation, for example, can bring thermal discomfort and possible changes in the microclimate, and as these areas also assume a role of leisure and recreation of the population, the lack of these spaces interferes with their quality of life.” Guimarães [1]. So, this reduction interferes negatively in the sustainable balance, in addition, the community does not understand that because of this absence there are environmental impacts that affect the entire community and potentiate the sensations arising from the greenhouse effect.

According Brazil [2] Environmental Education comprises the processes through which the individual and the community build social values, knowledge, skills, attitudes, and competences aimed at environmental conservation to achieve quality of life and sustainability. The methodology used had the purpose of sensitizing the school community of Araguanã and Zé Doca about the creation and conservation of urban green areas, the didactic sessions were carried out with high school students during Biology classes. Created based on the aspects of Brazil [3], specifically in Natural Sciences and its Technologies.

Initially, a preliminary approach was carried out through a questionnaire about the students' knowledge about environmental conservation and green areas. The questions asked were 1) What do you understand about environmental conservation? 2) Have you ever heard about environmental education? 3) What do you understand about green areas? 4) How important are they in cities? 5) In your opinion, who benefits from the creation and preservation of these areas in cities?

Of the 40 students, 30 showed basic knowledge on the subject (75%), the others (25%) showed more knowledge on the subject. For the students, 27 (67.5%) described their presence in cities as being of great importance, the other 13 (32.5%) did not know how to answer clearly.

After the application of the questionnaire, the workshops were carried out to consolidate the knowledge on the subject addressed and to enable other interactions between them and the theme. After carrying out them, the theme aroused their interest. For some there were significant changes in their responses from the interactions and discussions held.

Since environmental education is a continuous process through which students acquire knowledge and information on how to intervene directly in environmental impact and conservation, as showed by Lima end Amorim [4], it needs to go beyond schools, being possible agents that transform reality, fighting for the creation and preservation of urban green areas, thus enabling a better quality of life in cities.

Keywords: Urban Green Areas, Environmental Education, Quality of Life.

References

[1] L. G. Guimarães, "Estratégias de Infraestrutura Verde Aplicadas à Drenagem Urbana em Áreas Densamente Ocupadas: O Caso do Trecho 3 do Setor Habitacional Sol Nascente". Dissertação de Mestrado em Tecnologia Ambiental e Recursos Hídricos, Publicação PTARH. Departamento de Engenharia Civil e Ambiental, Universidade de Brasília, Brasília, DF, 2019.

[2] Brasil. Decreto-lei n. 9795, de 27 de abril de 1999. Dispõe sobre a Educação Ambiental e institui a Política Nacional de Educação Ambiental e dá outras providências. *Diário Oficial da República Federativa do Brasil*. Brasília, 1999. [online] Avaliable: http://www.planalto.gov.br/ccivil_03/leis/l9795.htm Acesso em: 21 jan. 2021

[3] Brasil. Ministério da Educação. *Base Nacional Comum Curricular*. Brasília, 2018.

[4] V. Lima and M. C. C. T. Amorim, "A importância das áreas verdes para a qualidade ambiental das cidades", *Formação (Online)*, vol. 1, no. 13, pp. 139 – 165, São Paulo, 2006. Accessed: 25 mai. 2022. Doi: 10.33081/formacao.v1i13.835 Avaliable in: https://revista.fct.unesp.br/index.php/formacao/article/view/835

Life Cycle Analysis and Kaizen in an Educational Institution: A Systematic Literature Review and Bibliometric Analysis

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Abstract

Tools aimed at promoting sustainability such as Life cycle Analysis (LCA) linked to continuous improvement tools such as Kaizen, if well combined, can contribute positively to an integrated waste management. The proposal is argued that the combined application of these two tools, can reduce or even eliminate problems in production chains waste management. The combination of kaizen and sustainable development is documented to increase quality, customer satisfaction, decreasing costs and reducing lead time [1]. The LCA is a key example of a well-known environmental practice [2]. Through LCA it is possible to quantify the impacts related to a specific process or the combination of these processes within waste management. In LCA environmental aspects of each stage of the materials production process and services are considered until their disposal [3].

The educational institutions are important vectors of knowledge and propagation of innovation concepts, they can contribute to boost knowledge, culture, human values, and progress [4] and impact their immediate environment but also along their value chains, thus calling for life cycle approach [5]. For this the idea of this work is the application of these tools in educational institutions context.

In order to carry out research a literature review on LCA and Kaizen in Educational Institutions, the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) method was used. For the bibliometric research, the software OpenRefine and VOSviewer were used for data handling. Therefore, both methodology and the software have been increasingly applied for scientific advancement [6], and can maximize the chances of reaching the objective of the study, with greater precision and more data.

The systematic review of the literature through the PRISMA showed the relationship of LCA and Kaizen in the Educational Institution considering the twenty articles – the highest number of citation and the published year and concluded that there are no studies with the application of combined methodologies (LCA and Kaizen) in educational institution. However, it was identified that Kaizen can be very well applied in services, by combining methodologies that can contribute to the improvement of educational institutions in both financial, environmental and social dimensions [7]. In addition, analysing information such as authors, research areas, research objective, research focus and main findings, it was possible to verify the scope of the articles studied in the performance of the triple bottom line (TBL) - Social, Environmental, Financial and models, which consider the three performances. Thus, through the analyzed models, it was possible to design one that could be applied to LCA and Kaizen in an educational institution.

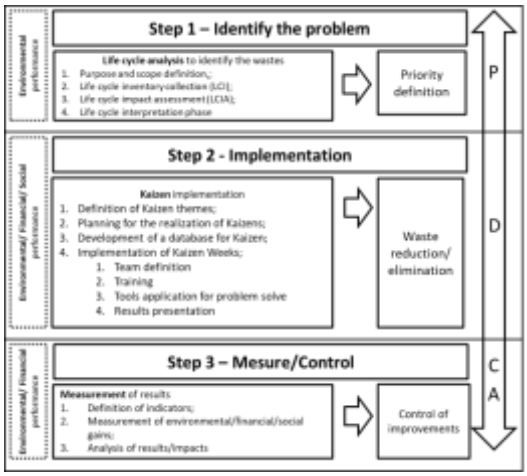

Figure 1 - Proposed model to improve the economic, environmental and social performance

The first step of the model is to identify the problem or define the institution's priority. In this way, it is possible to use the LCA to identify the waste to be worked on. Given that the LCA helps companies assessing the environmental impacts associated with each stage in a product's life cycle and to identify the "hot spots," or most important environmental impacts across the supply chain [8], this phase that through the collection of substantial amounts of data to analyze a product/waste to be defined to be worked on. The result of this phase will form the basis for the beginning of the next step. The second phase begins with the objective of improving the issues that had the greatest environmental impact on the institution, according to the LCA carried out in the first step. In this way, the Kaizens themes will be defined, planned, a database will be developed and the weeks Kaizens will be implemented, considering the team definition, training, tools application and results presentation. The third phase will take place through the measurement of the results obtained in the developed Kaizens. It is important to define the indicators (from the database developed), measurement of environmental, financial and social gains and analysis of results/impacts in terms of sustainability in the educational institution studied.

Keywords: Life Cycle Analysis; Kaizen; Educational Institution; Literature Review; Bibliometric Analysis

References

[1] Nitin, S. Deshmukh and G. Suresh, "Lean Manufacturing for Sustainable Development", in *Global Business and Management Research: An International Journal*, Vol. 2, Nr.1, 2010, pp. 125-137.

[2] A.B. Pampanelli, P. Found, A.M. Bernardes, "A Lean & Green Model for a production cell" in *Journal of Cleaner Production*, Dec. 2014, pp. 19-30.

[3] A. Ramos and A. Rouboa, "Renewable energy from solid waste: life cycle analysis and social welfare" in *Enviromental Impact Assessment Review*, Nov. 2020, pp. 1-12

[4] A.E. Tolosa, G. Bueno, I. Etxano, U. Tamayo, M. Garcia, M. Blas, E. Iribarren, I. Zuazo, E.T. Pascual, O.A. Gardoki, "Social organisational LCA for the academic activity of the University of the Basque Country UPV/EHU" in *The International Journal of Life Cycle Assessment*, Jul. 2021,pp.1648–1669

[5] R. Lozano, K. Ceulemans, M. Alonso-Almeida "A review of commitment and implementation of sustainable development in higher education: results from a worldwide survey" in *Journal Clean Production*, Dec. 2015, pp 1–18.

[6] R.A.M. Boloy, A.C. Reis, E.M. Rios, J.A.S. Martins, L.O. Soares, V.A.S. Machado, D.R. Moraes, "Waste-to-Energy Technologies Towards Circular Economy: a Systematic Literature Review and Bibliometric Analysis" in *Water Air Soil Pollut*, Jul. 2021, pp. 232-306

[7] P. Danese, V. Manfè, P. Romano "A Systematic Literature Review on Recent Lean Research: State-of-the-art and Future Directions" in *International Journal of Management Reviews*, Apr. 2018, pp. 579-605

[8] D. O'Rourke, "The science of sustainable supply chains" in *Science,* Jun. 2014, pp. 1124-1127.

Waste Collection Problem Solution Using Open-Source Tool

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Abstract

The world population increased significantly during the last century, with a major relocation from rural to urban areas being observed. With the population shift to urban areas, cities worldwide have been facing complex problems in providing adequate services to citizens, such as health, education, traffic and waste management. The waste generated in cities is one of the most complex problems to manage due to intricate composition and stochastic generation. Most recent data (2018) registered a waste generation of 195 million tonnes of municipal solid waste (MSW) from European Countries, representing around 500 kg of waste generated per capita [1]. The municipal solid waste management system (MSWMS) requires innovative strategies to deal with increasing difficulty and waste content. One of the tasks in this system that has been the focus of studies towards optimization is the waste collection, which is responsible for a significant share of total operational costs. In most cities/companies dealing with MSW, this task is performed in a traditional way, in which drivers are responsible for route planning, or the route is previously planned and scheduled. This approach can lead to inefficient time and fuel expenditure once the trucks might travel to empty dumpsters or even take longer to collect full dumpsters.

In this scenario, with the constant evolution of information and communication technologies, the waste management sector could take advantage of this to improve overall performance. One particular strategy that has shown promising results is the use of Wireless Sensors Network to collect real-time data regarding the waste level and apply this information for route planning. In this solution, the physical network contains real data, and the optimization algorithm uses this data as input to find the shortest path for waste collection [2]. The literature on this topic is rich with different problems developed to model the real scenario, most considering the known vehicle routing problem (VRP) as starting approach. Due to the increased interest in waste collection, a new formulation of the VRP arose, the Waste Collection Problem (WCP). In brief, this formulation considers multiple dumpsters that need collection and a set of trucks that can be used to collect these dumpsters, with only one central depot. The objective of the problem is then summarized on the collection of the waste following the shortest path. Like the classic VRP, WCP also has different variations, each considering specific constraints to approach the formulation from the actual situation [3].

In this work, three metaheuristic algorithms available in Open-Source Google OR-Tools were assessed to optimize the waste collection of 20 paper waste dumpsters in the city of Bragança, Portugal. Waste level throughout the days studied was determined based on a stochastic approach, considering the region nearby each dumpster. The complete system is comprised of 3 modules: i) initialization and levels update, ii) selection of dumpsters to be collected, and iii) route optimization. The initial level in module *i* was defined using uniform distribution probability, and module *ii* selects all dumpsters for collection once every two days. Modules *i* and *ii* exchange information to set levels to 0 once dumpsters are emptied. Finally, the third module will find the best route for collection days using Guided Local Search (GLS), Tabu Search (TS), and Simulated Annealing (SA). It is essential to highlight that algorithms solve the problem modeled as Capacitated Waste Collection Problem. In other words, the objective is to collect all the waste from dumpsters in collection days on the shortest path, without ever exceeding the capacity of the vehicles. The period considered for this study was 30 days, and three

trucks were assigned for the waste collection.

At the end of 30 days, it was possible to observe that load carried was the same, and the total distance traveled was similar using the three algorithms, with an advantage for GLS compared to SA and TS. This result shows that all three options of search algorithms available in the tool are good for route optimization. For instance, total distances traveled were 339.779, 345.933 and 351.840 km using GLS, TS, and SA, respectively. Each algorithm also returns daily routes followed, which allows the graphical representation of pathways for comparison purposes, as shown in Figure 1. Furthermore, a comparison of the collection cost was carried out between the optimized solutions and the company's real scenarios practiced today. This comparative analysis revealed the reduction of at least 6 euros per m^3 of waste collected using the routes proposed by the algorithms to improve waste collection.

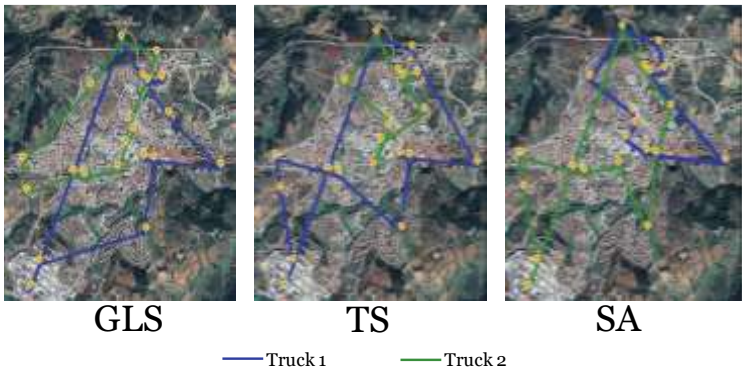

Figure 1 - Graphical representation of collection routes for different algorithms.

Keywords: Waste Collection Problem, Optimization, Google OR-Tools.

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References

[1] S. Kaza, L. Yao, P. Bhada-Tata and F. Van Woerden, *What a waste 2.0 - A Global Snapshot of Solid Waste Management to 2050*. Washington, DC. [Online]. Available: https://openknowledge.worldbank.org/handle/10986/30317

[2] S. R. J. Ramson and D. J. Moni, "Wireless sensor networks based smart bin", *Comput. Electr. Eng.*, vol. 64, pp. 337–353, 2017, doi: 10.1016/j.compeleceng.2016.11.030.

[3] J. Mandziuk, "New shades of the vehicle routing problem: Emerging problem formulations and computational intelligence solution methods", *IEEE Trans. Emerg. Top. Comput. Intell.*, vol. 3, no. 3, pp. 230–244, 2019, doi: 10.1109/TETCI.2018.2886585.

Adaptive System to Manage Everyday User Comfort Preferences

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Abstract

Urban mobility brings many challenges and opportunities, particularly regarding sustainability. It is natural that we want better living conditions, we are naturally given to consuming, even when there is no need, we increasingly want to travel, socialize, enjoy and it is not easy to accept that we will most likely have to change. It is no longer a distant future, but the present that we are living. Even in the face of successful solutions, receptivity is far from being massified and in most cases it imposes compromises in terms of comfort and quality of life, sometimes even imposing new habits and ways of being.

In addition, not all of us have the same perception of the situation seriousness, or the same willingness to compromise. And this can happen for numerous reasons, namely physical or health limitations, financial limitations, different beliefs/motivations, or different ways of facing problems. It is even common that the staunchest defender of certain solutions, when faced with other equally plausible solutions, is completely insensitive or even opposed. In fact, the same individual may have different needs/preferences relatively to the place where he is or the activity he is performing, that is, preferences that vary with time and place. In a broader context of mobility, in which individuals in their daily lives move and visit different places, often with the presence of more people, the situation is even more complex, the variability of preferences increases, and it is necessary to combine preferences/needs of different individuals.

Emerging technologies, within the Internet of Things (IoT) scope and smart spaces [1], allow us to aspire to capable solutions in line with the urban mobility and sustainability demands and, at the same time, to promote better conditions of comfort and well-being, without imposing sacrifices or changes in habits and considering the specificities of each individual, at different time and place.

These solutions whose success depends in part on the autonomy of operation, not requiring any direct and conscious participation of people, for the ability to make the best decisions given the current context and future expectations, the context being defined by the characteristics of the environment. Including the dynamics, namely those resulting from the presence/involvement of people, but also for the transparency of action, not being evasive and, if possible, fulfilling its function without people realizing the existence of the technology/solution simply the most convenient happens. There are other factors that should not be neglected, such as those related to security and privacy. In this paper, the authors propose an architecture that considers these requirements so that, in a non-evasive way, it adapts the different spaces that the user frequents (house, work, leisure, others) to their personal preferences, such as temperature, humidity, sound, environment, etc.

The architecture includes the different devices needed, to identify users, as well as the communication technologies to be used to transfer the preferences of each user to the system. The architecture includes a multi-agent system that allows managing conflicts of preferences through a user's hierarchy and that considers safety values for each preference, to safeguard the different actuators (air conditioning, fan coils, multimedia, etc.) present in space. It was developed, focusing on the definition of each user's preferences in a smartphone application, which allows the user's preferences to be transferred to the space, without the need to perform any interaction, they can also be passed through smartwatches, fitness bracelets and similar devices, which currently have different communication technologies such as Bluetooth Low Energy (BLE), Near Field Communication (NFC) or Wifi-Direct. It also contains a local processing solution, currently supported by a Raspberry Pi, and will be present in each space where we want to adapt to different preferences. Each of these systems constantly receives each present user preferences. Based on the multi-agent system, it calculates the

optimal preferences to be applied to each space at a given time. It is also responsible for sending these to the different actuators present in the space.

The multi-agent system has different layers (simulation, data acquisition, user information, actuation) [2]. Briefly, there is an agent for each user present, containing their preferences, and there is an agent that represents the space, containing eventual constraints, such as security values and others that may exist, namely in public spaces. Each of these agents aims to represent the interests of the involved parties. For example, the agent representing the space should be focused on an efficient use of equipment, minimizing energy costs, enhancing the durability of the equipment, minimizing maintenance costs. Taking advantage of the different hierarchies, an equation was devised that meets the different preferences to define the optimal solution, which will be sent to the different actuators.

$$prefValue = \frac{\sum_{user=1}^{n} uP * uHP + (sP * sProp)}{\sum_{user=1}^{n} uHP + sProp} \quad (1)$$

In (1), is depicted the equation for calculate the preference value to apply in the actuators present at the space. In this equation we have: *n* - number of users present in space; *uP* - each user preference for the space; *uHP* - each user hierarchy proportion; *sP* - space preference; *sProp* - space proportion.
For the equation, different hierarchical proportions defined to respond to different possible situations were used, namely introducing the concept of family (parents/children) for the domestic space, the concept of employee/boss in the professional space, and the concept of owner/responsible of space in different public spaces. The entire architecture was implemented at this stage in the testing process, to be able to assess its performance. Different parameters were defined to assess the performance of the multi-agent solution, namely the following: Number of agents used, Agent speed reasoning, Information filtering, Environment perception time.

The entire component referring to the privacy and security of users' information was also carried out, using anonymization techniques to eliminate any user identification possibility, as it would be critical to have the entire history of a particular person containing the information of the places that attended and respective hours. From the analysed state of art, it was concluded that there are only small and isolated projects, which aim to analyse this problem, and a solution that satisfactorily meets the needs of this new reality and its specificities has not yet been developed. It can then be concluded that this work will make a significant contribution to the field of sustainable urban mobility, achieving maximum comfort for the user in the different spaces that he frequents in his daily routine, and it is still possible to maximize efficiency.

Keywords: Adaptive-System, AmI, Multi-Agent, IoT, Actuators, Preferences, Constraints.

References

[1] Learning frequent behaviours of the users in Intelligent Environments. Asier Aztiria, Juan Carlos Augusto, Rosa Basagoiti, Alberto Izaguirre and Diane J. Cook. IEEE's Transactions on Systems, Man and Cybernetics: Systems 43(6):1265-1278, Nov 2013. IEEE Press

[2] Learning patterns in Ambient Intelligence environments: A Survey. Asier Aztiria, Alberto Izaguirre, Juan Carlos Augusto. Artificial Intelligence Review, Volume 34, Number 1, 35-51, June 2010.

Potential Reduction of Greenhouse Gas Emissions Through Vehicle Electrification: A Bibliometric Analysis

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Abstract

The European Union (EU) aims to be net-zero greenhouse gas emissions by 2050, in line with the EU's commitment under the Paris Agreement from 2015. Several policies are being implemented to pursue this goal, and in the 30 year period (1990-2020) there has been a significant decrease of the emissions of about 34% [1], due to mainly the penetration of renewables and improvements in the energy efficiency. Also, the Covid-19 pandemic and the associated recession contributed to the decrease measured in 2020. Besides the foreseeable economic takeoff, the majority of the sectors have been decreasing their emissions, with the exception of the transport sector, refrigeration and air conditioning [1]. In this context, the vehicle fleet electrification provides a vital step to a climate-neutral economy transition [2,3], being a promising way to reduce GHG emissions.

By 2020, more than one in ten vehicles registered in the EU were electric, increasing by a total of around 1 million units over the seven-year period [4]. However, electric vehicle (EV) adoption faces several barriers, including high purchase price, long recharging time, reduced range, and lack of charging facilities [2]. From these considerations, the following question arises: without attractive customer costs, the electric based technologies will not enter the market and the goal of reducing GHG emissions will not be achievable? On the other hand, the actual trend of expanding battery size to improve EV autonomy can be detrimental to GHG impacts [5]. Nevertheless, the ambitious EU road transport CO_2 reductions may be technically feasible by 2050, it should be kept in mind that delayed actions in 2020-2030 may compromise the achievement of the targets [6, 7].

Governments should consider significant investments and incentives, including improvements of European renewable electricity production, development of new infrastructure across Europe (charging stations) [4, 6] and significant and sustainable political incentives such as purchase subsidies [4]. Furthermore, there is sufficient evidence to state that, in most countries, GHG mitigation in the transport sector requires the implementation of strong and integrated policy mixes [8] taking into account consumer behaviour [5]. Therefore, it follows that electromobility targets should be implemented not only on a local scale, but also on a national and global scale.

The context above motivates the actual research to analyse how the literature has been discussing GHG reduction through vehicle fleet electrification. Furthermore, it was verified that studies particularly focus on empirical investigations, which reveals the need for a study that analyses the evolution of the research field, so far. To this end, it was decided to carry out a bibliometric analysis using the *software Biblioshiny* [9] *from the Bibliometrix* R package [10]. Initially, the *Web of Science database* was used and the keywords "GHG", "electric vehicle", "road" and "transport" were used, which resulted in 660 documents. Subsequently, inclusion criteria were specified to screen studies, which reduced the sample to 320 articles. Still, having found that some studies did not meet the objective, the selection process was carried out by analysing the titles of the documents, resulting in a final sample of 222 scientific studies. Content analysis was performed based on the main documents, according to the number of citations.

The bibliometric analysis showed that there has been a growing interest in the theme, since 68.47% of the papers were published in the last five years (2018-2022). From the scientific production, geographically, it was found that China (n=159), the USA (n=105), and the UK (n=90) were the main producers in the field of EVs for GHG emissions reduction. Furthermore, the journal "Transportation Research Part D-Transport and

Environment" proved to be the most published in this field of research. The thematic evolution provided a global view of the changes, highlighting that GHG emissions, energy, consumption, electric vehicles and efficiency present themselves as the main directions to advance the thematic discussion. Furthermore, the thematic map provided promising information for researchers in the field of EVs' penetration to mitigate GHG emissions, since it presented the level of development and relevance of each of the topics addressed. It could be observed that studies related to (i) EVs to reduce GHG emissions and (ii) energy consumption to answer to climate change corresponds to the development trend of this research field. Given the importance of EVs in mitigating GHG emissions, further discussions and research on strategies and policies need to be considered. Furthermore, it is suggested that governments offer more incentives to deploy EV adoption in order to address significantly high fuel economy and ultra-low and even zero disposal GHG emissions. The work developed aims to give future researchers in this scientific field awareness of the most significant paths of the potential reduction of GHG emissions, in the short and medium terms.

Keywords: GHG Emissions, Electric mobility, Bibliometric Analysis.

References

[1] European Environment Agency (EEA), "Annual European Union greenhouse gas inventory 1990-2020 and inventory report 2022", 2022. https://www.eea.europa.eu//publications/annual-european-union-greenhouse-gas-1 (accessed Jun. 16, 2022).

[2] H. Liu and D. Z. W. Wang, "Locating multiple types of charging facilities for battery electric vehicles," *Transportation Research Part B: Methodological,* vol. 103, pp. 30-55, Sep. 2017, doi: 10.1016/j.trb.2017.01.005.

[3] P. Jochem, C. Doll, and W. Fichtner, "External costs of electric vehicles," Transportation *Research Part D: Transport and Environment*, vol. 42, pp. 60-76, Jan. 2016, doi: 10.1016/j.trd.2015.09.022.

[4] ACEA, "Making the transition to zero-emission mobility - ACEA - European Automobile Manufacturers' Association 2021", 2021. https://www.acea.auto/publication/2021-progress-report-making-the-transition-to-zero-emission-mobility/

[5] C. Ternel, A. Bouter, and J. Melgar, "Life cycle assessment of mid-range passenger cars powered by liquid and gaseous biofuels: Comparison with greenhouse gas emissions of electric vehicles and forecast to 2030," *Transportation Research Part D: Transport and Environment*, vol. 97, Aug. 2021, doi: 10.1016/j.trd.2021.102897.

[6] J. Krause *et al.* , "EU road vehicle energy consumption and CO2 emissions by 2050 - Expert-based scenarios," *Energy Policy*, vol. 138, Mar. 2020, doi: 10.1016/j.enpol.2019.111224.

[7] P. Siskos, G. Zazias, A. Petropoulos, S. Evangelopoulou, and P. Capros, "Implications of delaying transport decarbonisation in the EU: A systems analysis using the PRIMES model," *Energy Policy*, vol. 121, pp. 48-60, Oct. 2018, doi: 10.1016/j.enpol.2018.06.016.

[8] J. Axsen, P. Plötz, and M. Wolinetz, "Crafting strong, integrated policy mixes for deep CO2 mitigation in road transport," *Nature Climate Change*, vol. 10, no. 9, pp. 809-818, Sep. 2020, doi: 10.1038/s41558-020-0877-y.

[9] M. Aria and C. Cuccurullo, "Bibliometrix: An R-tool for comprehensive science mapping analysis," *Journal of Informetrics*, vol. 11, no. 4, pp. 959-975, Nov. 2017, doi: 10.1016/j.joi.2017.08.007.

[10] R. C. Team, "R: a language and environment for statistical computing," *R Foundation for Statistical Computing,* Vienna, Austria. 2012, 2021.

Technological Perspectives and Economic Aspects of Green Hydrogen in the Energetic Transition: Challenges for Chemistry

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Abstract

Since the Paris Climate Agreement in 2015, governments and businesses worldwide have stepped up, taking the actions needed to reach a global average temperature target well below 2 °C above the pre-industrial levels [1]. Several initiatives are related to reducing greenhouse gas (GHG) emissions (CO_2, CO, NO_x, among others) that can occur with the use of technologies aimed at decarbonizing various sectors. Many initiatives have been taken to solve this problem, including encouraging and using biofuels such as biodiesel[2,3] and ethanol. However, green H_2 has been standing out in recent years due to its properties and application possibilities. The global shift toward contributing to meet the Sustainable Development Goals (SDGs) and decarbonization has triggered a substantial boost in the hydrogen (H_2) industry. This industry, in turn, offers several alternatives for the use of hydrogen in the transition toward a low-carbon economy: as an energy carrier and storage medium for conversion back to electricity, as a fuel for all modes of transport and mobility, and as a potential substitute for fossil hydrocarbons in industries such as steel and petrochemicals. H_2 has gained importance because it is a carbon-free fuel with high heating value and a high energy carrier with less volume, which can significantly reduce carbon emissions [2].

A carbon-free hydrogen society has been the goal of the hydrogen energy transition. Thus, the production of the so-called green H_2 has been approached preferentially based on hydrogen production through the electrolysis of water using renewable energy sources. These processes have been in progress for some time, and the production of hydrogen via alkaline water electrolysis is now a mature technology with commercially available megawatt (MW) scale installations [2]. In this sense, there are two paths to produce "clean" H_2: (i) production from nonrenewable raw material sources (*e.g.,* natural gas) together with carbon capture and sequestration, or (ii) H_2 production, avoiding and/or minimizing the formation of CO_2 and making use of renewable sources of raw materials (*e.g.,* biomass, biogas, among others) and energy (*e.g.,* solar, wind, among others). The latter include the so-called zero-carbon routes, without CO_2 generation and with low carbon (with CO_2 generation reduced to acceptable levels). Furthermore, the production of H_2 requires an abundant amount of low-cost water or simple hydrocarbons (preferably methane). Green H_2 consumes at least 9 kg of water per kg of H_2, while gray and blue H_2 require half this amount (when produced by steam reforming methane with a gas–water exchange reaction). Indeed, water is a limited resource in many regions, with uses in several sectors, such as energy, agriculture, and sanitation. In many regions, the scarcity of this resource does not allow for the production necessary to meet local demand. In addition to the higher water consumption, green H_2 requires approximately 11 times more energy per unit of H_2 produced when compared with non-renewable routes (before carbon capture), which need to be cheap [2-4].

Greening the global H_2 supply would require approximately 3.90 TWh of electricity annually, representing 60% more than the combined energy generated globally by wind and solar photovoltaics in 2020 (2.44 TWh). Currently, electrolyzers can only reach the competitive limit of USD 2 kg^{-1} when operating on "free" electricity 30% of the time or more, dramatically limiting the supply of H_2. In 2020, without the necessary demand, 1.6 TWh of renewable energy had to be wasted by the California Independent System Operator (CAISO), an amount corresponding to 28.9 kt H_2. However, CAISO data show that only 50 MW electrolyzers could achieve a capacity factor of 30% of the wasted energy, enough to produce only 451 t of H_2. While H_2 is seen as an alternative to

reduce the waste of excess renewable energy, converting the excess energy into H_2 may subsequently reflect losses of up to 70% in turbines or fuel cells (energy→gas→energy). The simplest solution to avoid wasting energy would be to increase demand. The problem lies in a business model that focuses on the worldwide use of electrolyzers, whose production cost is not yet appealing for industries to start buying energy to produce green H_2 continuously, thus causing intermittent production. On the other hand, blue H_2 is not associated with the electricity supply network, has a low cost, and can be continuously produced, as methane is also continuously produced in several locations. Projects related to green H_2 production are still expensive compared with those using fossil fuels. According to the International Energy Agency (IEA), green H_2 from wind energy costs between USD 4-10 kg^{-1} and USD 7-17 kg^{-1} when solar energy is used, while gray H_2 produced from fossil fuels costs USD 1-2.50 kg^{-1}. However, the production of gray H_2 generates close to 9.5 kg CO_2 kg^{-1} H_2. For this reason, the carbon market becomes an ally for projects involving green H_2 to become economically viable [2,5].

In summary, the main purpose of using H_2 is to decarbonize the economy, and it makes sense to use the H_2 that offers the most significant environmental benefit. However, there are cases where the use of blue H_2 is more appropriate. For instance, if a natural gas plant has access to the entire transport infrastructure, it makes sense to use this H_2, contributing to emission reductions with a carbon capture process. Regardless of whether H_2 is green or blue, caution must be exercised when embarking on projects aimed at building new transport networks or H_2 plants based on non-renewable sources, due to the high construction cost of new infrastructure and the long-time horizon of these projects. It is necessary to include in the equation whether the option for blue H_2 with carbon capture will justify the investment in the long term [2].

Keywords: Green Hydrogen, Energy Transition and Sustainable Development, Decarbonization.

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References

[1] Agreement, P., In *Conference of the Parties to the United Nations Framework Convention on Climate Change (21st Session, 2015: Paris). Retrived December*; 2015; p. 2017.

[2] L. L. N. Guarieiro; Jeancarlo P. dos Anjos, Luciana A. Silva, Alex Á. B. Santos, Ewerton E. S. Calixto, Fernando L. P. Pessoa, José L. G. de Almeida, Miguel Andrade Filho, Flavio S. Marinho, Gisele O. da Rocha, and Jailson B. de Andrade, "Technological perspectives and economic aspects of green hydrogen in the energetic transition: challenges for chemistry," *J. Braz. Chem. Soc.*, vol. 33, no. 8, pp. 844-869, 2022, doi: 10.21577/0103-5053.20220052.

[3] Gisele O. da Rocha, Jeancarlo P. dos Anjos, and Jailson B. de Andrade, "Water Challenges and solutions for Brazil and South America", In *Water Challenges and solutions on a Global Scale, ACS Symposium Series; American Chemical Society: Washington, DC, 2015*; pp. 71-94.

[4] Gisele O. da Rocha, Jeancarlo P. dos Anjos, and Jailson P. de Andrade, "Energy trends and the water-energy binomium for Brazil". *An. Acad. Bras. Cienc.*, v. 87, pp. 569-594, 2015, doi: 10.1590/0001-3765201520140560.

[5] IEA The Future of Hydrogen: Seizing today's opportunities, https://www.iea.org/reports/the-future-of-hydrogen (accessed Sep 15, 2021).

Activity of Carbon Black/PTFE Composites Materials for Electrochemical Hydrogen Peroxide Production

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Abstract

During the last decades, the performance of carbonaceous electrodes in water and wastewater treatment by means of capacitive deionisation (electrosorption), electro-oxidation, and electrodeposition has caught growing interest among researchers. Porous carbon-based electrodes typically provide a high surface area and hence, rate of electron transfer and electrocatalytic active sites [1]. The preparation of carbon electrodes requires binders, to agglomerate and retain the carbonaceous material particles that form the final electrode. Fluorine-containing resin materials such as polytetrafluoroethylene (PTFE) are widely used as a binder, as they have an excellent chemical and thermal resistance [1]. For this reason, PTFE has been widely used as a binder for the fabrication of carbonaceous cathodes for energy storage, particularly in microbial fuel cells and capacitor/supercapacitor devices. Cathodes prepared by deposition of carbon black (CB) on carbon felt using PTFE as binder have shown promising results for *in-situ* production of H_2O_2. This fact is particularly relevant for their application in electro Fenton systems for the oxidation of bio-recalcitrant organic pollutants in wastewater [1]. An effective electrochemical H_2O_2 production is a potential advantage for Fenton-like systems which have the oxidant as one of the main operational costs [2].

In this work, carbon-based cathodes based on CB and PTFE were prepared using only these components (non-supported on carbon felt), as shown in Fig. 1. For that purpose, 5 g of 60 wt.% PTFE (Sigma-Aldrich) and 1 g of CB (acetylene, 100 % compressed, supplied from Alfa Aesar) were mixed in water (Fig. 1a). The paste obtained was kneaded and pressed in a stainless-steel mould (Fig. 1d) and afterward, the electrode was demoulded to obtain rectangular cathodes with size 30x50x3 mm (Fig. 1c). Finally, the cathodes were dried at 80 °C overnight, and later they were calcined at 360 °C for 1 h (Fig. 1d).

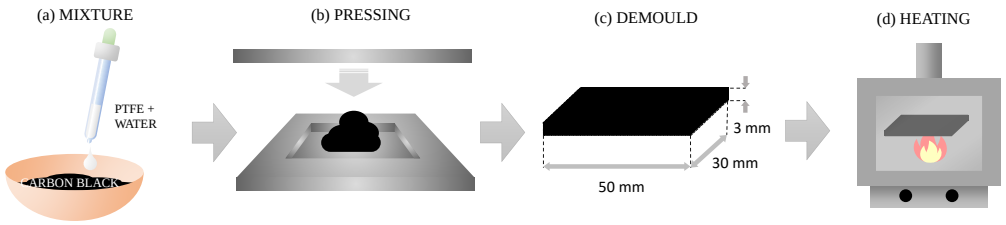

Figure 1 - Schematic procedure of flat carbon electrodes based on CB and PTFE.

The performance of the cathode was tested in a non-pressurized undivided electrochemical chamber working with 80 mL volume (V) using a platinum electrode as anode (2.25 cm^2) with a separation distance of 25 mm from the CB-based cathode (submerged surface area of 12 cm^2). In a typical run, 80 mL of 50 mM Na_2SO_4 was placed in the reactor's chamber after the appropriate adjustment of the pH to 3 with 1 M H_2SO_4. The chamber was continuously bubbled with 0.5 mL min^{-1} air by a peristaltic pump and magnetically stirred. The electrochemical hydrogen peroxide production from oxygen reduction was monitored upon reaction time (t), taking samples periodically, during 3 h. Different current intensities (I) were explored and the concentration of H_2O_2 ($C_{H_2O_2}$) was determined by $TiOSO_4$ colorimetry method at a wavelength of 405 nm [3]. The current efficiency (CE) was determined as $CE = 2 \cdot F \cdot C_{H_2O_2} \cdot V/(I \cdot t)$, where F refers the Faraday constant (96 487 C mol^{-1}) [1].

Figure 2 represents the H_2O_2 production obtained with the same CB/PTFE carbon-based electrode applying different current intensities. Activity decays from the first use of the cathode until the third one (data not shown). Thereafter, the oxidant production was kept constant, and the cathode was used at the different current intensities for more than once to assure a reproducible behavior. The working potentials observed was constant upon the reaction time and reach values of 2.4, 3.2, 4.1, 5.0, 6.0 and 6.9 V for the applied current intensity of 6, 12, 24, 36, 48 and 60 mA, respectively. The hydrogen production was kept only by washing with distilled water (non-aggressive methods were applied for its reusability). As observed, the carbon-based cathode can generate up to 199 mg/L of H_2O_2 at the highest current applied (60 mA). However, the current efficiency (*CE*) considerably decreased increasing the current applied, reaching 13 % at 60 mA, whereas 92% was obtained at 6 mA.

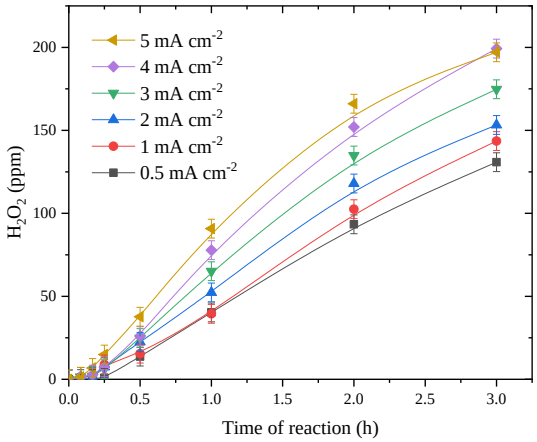

Figure 2 - Hydrogen peroxide production at different current intensity.

Keywords: Electrocatalyst, Electrolysis, Carbon Electrodes, Electro Fenton, Current Efficiency.

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References

[1] J.F. Pérez, A. Galia, M.A. Rodrigo, J. Llanos, S. Sabatino, C. Sáez, B. Schiavo, O. Scialdone, "Effect of pressure on the electrochemical generation of hydrogen peroxide in undivided cells on carbon felt electrodes" *in Electrochimica Acta* 248, Sept. 2017, pp. 169–177.

[2] J.L. Diaz de Tuesta, A. Quintanilla, D. Moreno, V.R. Ferro, J.A. Casas, "Simulation and Optimization of the CWPO Process by Combination of Aspen Plus and 6-Factor Doehlert Matrix: Towards Autothermal Operation" *in Catalyst* 10, May 2020, pp. 548.

[3] J.L. Diaz de Tuesta, F.V.M. de Almeida, J.R.P. Oliveira, P. Praça, M.C. Guerreiro, H.T. Gomes, "Kinetic insights on wet peroxide oxidation of caffeine using EDTA-functionalized low-cost catalysts prepared from compost generated in municipal solid waste treatment facilities" *in Environ. Tech. Innov.* 24, Sept. 2021, pp. 101984.

Occurrence of Polycyclic Aromatic Compounds in Different Environmental Compartments Around a large Brazilian Tropical Bay

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Abstract

Polycyclic aromatic compounds (PACs) are a large group of mainly anthropic-originated organic compounds. PACs include the well-known polycyclic aromatic hydrocarbons (PAHs), and their oxy- and nitro derivatives [1]. These organic pollutants are mainly originated from pyrogenic (incomplete fossil fuels burning and biomass combustion) and/or petrogenic (oil exploration and fossil fuels leaks) sources [2,3]. Intense road traffic and wood and fossil fuels burning (such as coal, gasoline, diesel, and kerosene) are the main sources that contribute to PACs emissions to the atmosphere [3]. They also may be transferred to other environmental compartments, becoming ubiquitous. Once in the atmosphere, high molecular weight PAHs and their derivatives (nitro-PAHs and oxy-PAHs), having high partition coefficient (log k_{ow}) and low vapor pressure, are mostly found in the fine particles (<2.5 μm) [2]. Therefore, they represent a serious concern to the human health once they can penetrate deep in the lungs. Thus, the investigation of the occurrence of PACs in fine particulate matter (PM2.5) is of utmost human health and environmental importance. In this work, we have reported the levels of PAHs and their oxy- and nitro-derivatives in PM10 and PM2.5 samples collected around Todos os Santos Bay (BTS), the second largest Brazilian bay. In turn, the occurrence of PACs in different environmental compartments such as water, sediments, and marine biota were also investigated.

PM10 and PM2.5 samples were collected in two different sites: (i) at an underground floor of a bus station (12°58'S, 38°30'W, 52 m altitude) where only heavy-duty vehicles fueled with biodiesel-diesel mixes are allowed (in Salvador, State of Bahia, Northeastern Brazil), and (ii) in a coastal area (BTS), which a mixed fleet were running with variable proportions of hydrated ethanol, gasoline, diesel, and biodiesel fuels at the sampling period. The analytes were extracted from PM samples using the microextraction procedure developed by Santos et al. [4]. Briefly, a 4.15 cm^2 filter section was cut off and extracted with 500 μL of dichloromethane:acetonitrile mixture (82 %:18%, v v^{-1}) using a miniaturized extraction device. The extract was injected into GC-MS in the single ion monitoring mode (SIM).

The results from the PM10 samples collected in the underground floor of a bus station showed the PAH levels ranged from <LOQ to 15.0 ng m^{-3}, whereas nitro- and oxy-PAHs concentrations ranged from <LOD to 69.4 ng m^{-3}, and from <LOQ to 115 ng m^{-3}, respectively. In general, the concentrations levels determined in this work for PAHs and its derivatives were similar to those observed in urban areas. However, the concentrations of the potent carcinogenic benzo[*a*]pyrene ranged from 1.42 to 4.49 ng m^{-3}, which exceeded the air quality standard established by the European Union (1.00 ng m^{-3}) [4]. Regarding PM2.5 samples, the concentration of PAHs and nitro-PAHs in the bus station ranged from 853 to 2025 pg m^{-3} and from 378 to 1305 pg m^{-3}, respectively, being higher than those determined in the coastal area (PAHs 0.32 – 122 pg m^{-3}, nitro-PAHs 95 – 414 pg m^{-3}) [5]. It is worth mentioning that the potent mutagens 2-nitrobenzathrone and 3-nitrobenzathrone were found in PM2.5 samples in concentrations ranging from 59 to 431-pg m^{-3}. Although the presence of these carcinogenic and mutagen compounds in PM2.5 may be a reason for concern, the cancer risk estimated by incremental lifetime cancer risk (ILCR) was calculated for both urban and coastal sites. The ILCR values calculated in this study presented low values, showing low cancer risk incidence although the ILCR values for the bus station were around 2.5 times higher than the ILCR from the coastal site [5].

Regarding PACs are ubiquitous pollutants, we also investigated their occurrence in polychaetes and ascidians. Once they are sessile organisms, we found that these organisms could be considered a more reliable pollution indicator instead of fishes. Regarding polychaetes, our finds showed that low molecular weight PAHs were the main species detected within the samples (100 % of detection frequency) and median concentrations ranging from 33 to 243 ng g^{-1} dw, whereas high molecular mass PAHs were detected with frequency detections ranging from 51.7 % (coronene) to 82.8 % (benzo[*a*]pyrene). Principal component analysis, ternary correlations, and diagnostic ratios were used to indicate principal contamination sources. Our data showed mixed sources, with petrogenic predominance over pyrogenic sources. This could be explained considering that BTS has an intense traffic of small boats and commercial ships, besides petroleum exploration and discharges of effluents from petrochemical industries. These activities have contributed to increasing the concentration of PAHs in sediments [6] and, consequently, in benthic organisms, such as polychaetes [7]. Besides PAHs, nitro-PAHs and oxy-PAHs were also detected in polychaetes [7]. The potent mutagenic 3-nitrobenzanthrone was found in all polychaetes samples, ranging from 110 – 5,180 ng g^{-1} dw. Benzanthrone, another important mutagenic compound, was found in concentrations ranging from <LOD to 520 ng g^{-1} dw. On the other hand, PAHs levels in ascidians ranged from <LOD to 278 ng g^{-1} dw. High molecular mass PAHs such as fluoranthene (<LOQ – 48.5 ng g^{-1}), pyrene (15.0 – 150 ng g^{-1}), chrysene (7.39 – 278 ng g-^{1}), benzo[*ghi*]perylene (26.9 – 45.7 ng g^{-1}), and coronene (9.12 – 165 ng g^{-1}) were found at higher concentration levels than the low molecular mass PAHs. This may indicate a significant contribution of pyrogenic sources. In addition to PAHs, oxy- and nitro-PAHs also were detected in ascidians samples but in a lesser quantity than polychaetes. 3-nitrobenzanthrone was only found below the limit of quantification in ascidians. In conclusion, we observed that polychaetes and ascidians have an interesting ability to bioaccumulate PAHs and PAH-derivatives and they might be useful as an indicator of marine pollution.

Keywords: 3-Nitrobenzanthrone, Polycyclic Aromatic Compounds, Airborne Particles.

References

[1] C. Achten, J.T. Andersson, Overview of Polycyclic Aromatic Compounds (PAC), Polycycl. Aromat. Compd. 35 (2015) 177–186. https://doi.org/10.1080/10406638.2014.994071.

[2] N.D. Dat, M.B. Chang, Review on characteristics of PAHs in atmosphere, anthropogenic sources and control technologies, Sci. Total Environ. 609 (2017) 682–693. https://doi.org/10.1016/j.scitotenv.2017.07.204.

[3] G. Lammel, Polycyclic Aromatic Compounds in the Atmosphere – A Review Identifying Research Needs, Polycycl. Aromat. Compd. 35 (2015) 316–329. https://doi.org/10.1080/10406638.2014.931870.

[4] A.G. Santos, A.C.D. Regis, G.O. Da Rocha, M.A. Bezerra, R.M. De Jesus, J.B. De Andrade, A simple , comprehensive , and miniaturized solvent extraction method for determination of particulate-phase polycyclic aromatic compounds in air, J. Chromatogr. A. 1435 (2016) 6–17. https://doi.org/10.1016/j.chroma.2016.01.018.

[5] A.G. Santos, G.O. Da Rocha, J.B. De Andrade, Occurrence of the potent mutagens 2- nitrobenzanthrone and 3-nitrobenzanthrone in fine airborne particles, Sci. Rep. 9 (2019) 1–13. https://doi.org/10.1038/s41598-018-37186-2.

[6] M.C.R. Sola, A.G. Santos, M.M. Nascimento, G.O. Da Rocha, J.B. De Andrade, Occurrence, sources, and risk assessment of unconventional polycyclic aromatic compounds in marine sediments from sandy beach intertidal zones, Sci. Total Environ. 810 (2022) 152019. https://doi.org/10.1016/j.scitotenv.2021.152019.

[7] M.C.R. Sola, A.G. Santos, S.T. Martinez, M.M. Nascimento, G.O. Da Rocha, J.B. De Andrade, Occurrence of 3-nitrobenzanthrone and other powerful mutagenic polycyclic aromatic compounds in living organisms: polychaetes, Sci. Rep. 10 (2020) 1–12. https://doi.org/10.1038/s41598-020-60369-9.

CO2 Fluxes through the Atmosphere/Grass Interface in an Urban Green Space Located in the North Interior of Portugal

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Abstract

Climate change has become one of the most worrying environmental issues today, as its effects cross all geographical borders. Currently, the great majority of the scientific community justifies the worsening of climate change due to the high emissions of Greenhouse Gases, such as carbon dioxide [1]–[3]. The challenge on this worrisome environmental problem is in finding sustainable and low-cost solutions to mitigate climate change effects, such as promoting urban green spaces as potentially relevant CO2 sinks [4]–[6].

In this study, we sought to evaluate the potential of a grass covered surface located in the city of Bragança, Portugal, as a carbon sink, by measuring carbon dioxide fluxes through its atmosphere/surface interface. This green space was subjected to regular grass cutting, during the period between February and June 2021. The CO2 fluxes were continuously measured using the LI-8100A system from LI-COR Biosciences ®, equipped with a transparent chamber. The study also involved monitoring edaphic and meteorological parameters, as well as vegetative parameters such as phytovolume and biomass produced.

The results obtained showed the existence of an expected intraday pattern in which the grass surface behaved as a sink during a considerable part of the solar hours and as an emitter in the complementary period (Fig. 1 (B)). This pattern was visible throughout the observation period, but it was marked by a decrease in CO_2 absorption capacity by the surface and, simultaneously, by an increase in emissions of this greenhouse gas, throughout the spring season (Fig. 1 (A)). This trend was also observed in other studies [7], [8].

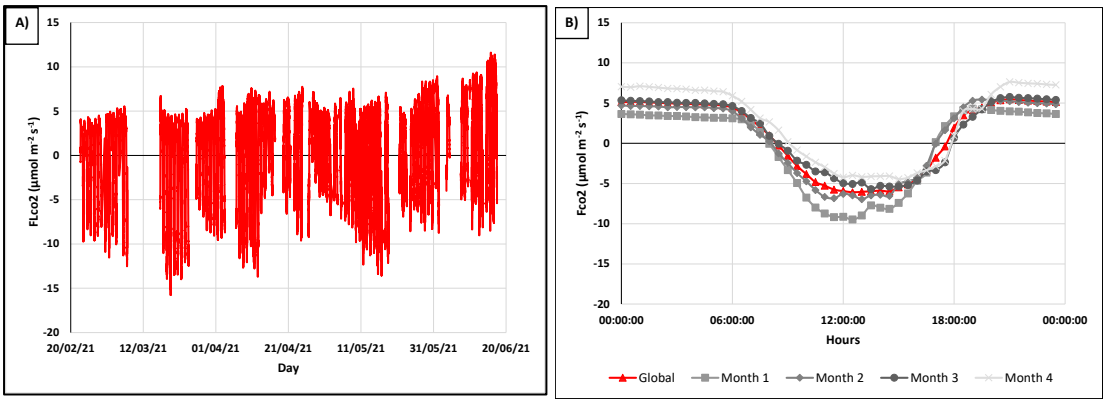

Figure 1 - CO_2 Fluxes. (A) Time evolution over the evaluation period; B) Comparison of the average daily profiles of each month of analysis.

In general, the surface behaved as a source of CO2 during the evaluation period, with a net emission flux of approximately 0.7 g C m-2 d-1. Studies carried out also show a positive mean term, indicating that the turf has a greater emitter characteristic in the spring period [7], [9]. However, the contribution of the turf as a sink for Greenhouse Gases, in relation to the absence of vegetation on the ground, minimized the upward CO2 fluxes, i.e., from surface to the atmosphere. In addition, possible human influences that can impair the sink

characteristics of the surface, such as irrigation and fertilizer applications, were observed. Another human action that disfavours the absorption of CO2 by the turf is the frequent cutting to which it is subjected, with the consequent reduction of photosynthetic capacity, due to the reduction of biomass that compromises the vegetative performance.

Keywords: Carbon Dioxide, Net Ecosystem Flux, Soil Respiration.

References

[1] IPCC, "Special report on global warming of 1.5 °C," 2018. https://www.ipcc.ch/sr15/ (accessed Sep. 14, 2021).

[2] O. B. Okedere and S. Oyelami, "Emission inventory of greenhouse gases and sustainable energy for mobile telecommunication facilities in Nigeria," *Environ. Challenges*, vol. 4, no. July, p. 100203, 2021, doi: 10.1016/j.envc.2021.100203.

[3] L. carlos B. Molion, "AQUECIMENTO GLOBAL : UMA VISÃO CRÍTICA," *Rev. Bras. Climatol.*, 2008.

[4] M. E. Jorat *et al.*, "Passive CO2 removal in urban soils: Evidence from brownfield sites," *Sci. Total Environ.*, vol. 703, p. 135573, 2020, doi: 10.1016/j.scitotenv.2019.135573.

[5] X. G. Wu, D. Hu, S. L. Ma, X. Zhang, Z. Guo, and K. J. Gaston, "Elevated soil CO2 efflux at the boundaries between impervious surfaces and urban greenspaces," *Atmos. Environ.*, vol. 141, pp. 375–378, 2016, doi: 10.1016/j.atmosenv.2016.06.050.

[6] K. J. Gaston, M. L. Ávila-Jiménez, and J. L. Edmondson, "Managing urban ecosystems for goods and services," *J. Appl. Ecol.*, vol. 50, no. 4, pp. 830–840, 2013, doi: 10.1111/1365-2664.12087.

[7] A. B. Willems *et al.*, "Carbon dioxide emissions from spring ploughing of grassland in Ireland," *Agric. Ecosyst. Environ.*, vol. 144, no. 1, pp. 347–351, 2011, doi: 10.1016/j.agee.2011.10.001.

[8] T. S. El-Madany *et al.*, "Drought and heatwave impacts on semi-arid ecosystems' carbon fluxes along a precipitation gradient: Drought and Heatwave Impacts," *Philos. Trans. R. Soc. B Biol. Sci.*, vol. 375, no. 1810, 2020, doi: 10.1098/rstb.2019.0519.

[9] F. Fang, X. Han, W. Liu, and M. Tang, "Carbon dioxide fluxes in a farmland ecosystem of the southern Chinese Loess Plateau measured using a chamber-based method," *PeerJ*, vol. 2020, no. 4, pp. 1–22, 2020, doi: 10.7717/peerj.8994.

Electric Vehicle Supply Chain Management: A Bibliometric and Systematic Review

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Abstract

This work aims to analyse the state-of-the art of the electric vehicle supply chain, through bibliometric and systematic reviews, using quantitative analysis indicators and qualitative analysis. The main objective is to analyse the electric vehicle supply chain in the period before and after the Covid-19 pandemic.

The analysis conducted in this work was based on documents found in the Scopus database, through the following String: TITLE-ABS-KEY(("electric vehicle*") AND ("supply chain" OR "supply chain management" OR "supply chain risk management" OR "supply chain resilience")). From the String used, 478 documents were found, and 81 articles were selected after applying filters. The bibliometric review was carried out with the support of the Bibliometrix software, using the following indicators: a) partnership between countries; (b) co-occurrence of the author's keywords; (c) publications per year; (d) publications by country; and (e) impact factor of journals.

In the systematic review, the PRISMA meta-analysis method was applied to analyse the ten most cited articles. Basically, this method is composed of a four-phases diagram, such as: (i) Identification, (ii) Screening, (iii) Eligibility and (iv) Included [1]. For the PRISMA meta-analysis, filters were applied to select only documents classified as articles, written in English, published between 2018-2022 and classified as open access.

According to the results, China presented the greatest international cooperation. This can be explained by its role as the main manufacturer of products in scale among emerging economy countries, allowing it to achieve competitive market prices. Brazil did not present documents published in international cooperation, but can contribute for reducing supply costs and minimizing the environmental impacts caused by the use of electricity from the burning of fossil fuels, because of its potential to generate renewable energy, such as solar and wind, in addition to having a mostly renewable electricity matrix (Energy Research Company - EPE, 2020).

Through the authors' keywords analysis, it was possible to observe that the life cycle analysis was the most recurrent type of analysis among studies on the electric vehicles supply chain and is directly linked to the environmental impacts caused by the consumption of electricity and the production of batteries.

It is important to emphasize the economic feasibility of implementing the electric vehicle. Upgrading the electricity grid just to support electric mobility could result in negative macroeconomic impacts. The costs of owning and driving were not calculated as much. It is because most recent studies have focused on reducing the production costs of fuel and electric vehicle components.

The lithium-ion battery was analysed in most studies found, especially about Chemical components, such as cobalt and lithium. The scarcity and disruptions of lithium, cobalt and nickel supply chains can hinder large-scale lithium-ion battery production, in addition to making it unfeasible for electric vehicles to have a 25% market share by 2050 [3]. It is very important to know the remaining battery life, as it is a factor that directly affects the supply chain and allows reducing the impact on demand-side management. (Wang et al. (2021).

Although the supply chain has been the focus of studies, supply chain risk management has been relatively less studied. Recently, the pandemic caused by the new Coronavirus has impacted several sectors due to the protective measures implemented to reduce contamination, such as lockdown. The Covid-19 pandemic also caused uncertainties in the neodymium-iron-boron (NdFeB) magnets supply chain, which is a magnetic type used in electronic components of the electric vehicle.

The years 2020 and 2021 were the most outstanding in terms of publications. Possibly, this highlight was due to the advance of the pandemic caused by Covid-19, bringing challenges to the supply chain. Brazil does not participate in publications on the topic. One possible explanation is that the electric vehicles used in the country are imported, not being produced on Brazilian soil.

The journals Energies, Sustainability, Applied Energy, and Energy Policy, which presented 8, 7, 3, and 3 published documents, had an h index equal to three, considering the articles published between 2018-2022.

Supply chain transparency for sustainability has not been studied as much. This is an important point, because by obtaining transparency between internal processes, it is possible to improve collaboration throughout the supply chain, from optimizing the traceability of raw materials, components and products [5].

Through the meta-analysis performed, it was possible to find some answers to the questions prepared. The raw material supply chain management has been extensively studied. However, the focus of the studies is on recycling components for reuse, through their remanufacturing. The environmental impact assessment was extremely important, and it is between the analyses conducted in the most cited articles. However, not only the environmental analysis must be done, but also the costs and profits analysis in the production chain. The most studied supply chain bias was the closed-loop supply chain, which considers the production chain and the collection of the product at the end of its useful life. Cobalt was clearly the most studied element. This is because, according to studies analysed in the bibliometric review, the demand for this metal tends to increase proportionally with the number of electric vehicles, since it compounds the lithium-ion battery.

It is hoped that the results presented here can help researchers in the conduction of new works and government agencies in the elaboration of the decisions to be taken.

Keywords: Bibliometric Review; PRISMA; Supply Chain Management; Systematic Review

References

[1] D. Moher *et al.*, "Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement," *PLoS Med.*, vol. 6, no. 7, 2009, doi: 10.1371/journal.pmed.1000097.

[2] Empresa de Pesquisa Energética - EPE, "Balanço Energético Nacional," Ministry of Mines and Energy, Brazil, 2020. [Online]. Available: http://www.epe.gov.br.

[3] M. Machedon-pisu and P. N. Borza, "A methodological approach to assess the impact of energy and raw materials constraints on the sustainable deployment of light-duty vehicles by 2050," *Sustain.*, vol. 13, no. 21, 2021, doi: 10.3390/su132111826.

[4] X. Wang, J. Li, B.-C. Shia, Y.-W. Kao, C.-W. Ho, and M.-C. Chen, "A novel prediction process of the remaining useful life of electric vehicle battery using real-world data," *Processes*, vol. 9, no. 12, 2021, doi: 10.3390/pr9122174.

[5] I. J. Fraser, M. Müller, and J. Schwarzkopf, "Transparency for multi-tier sustainable supply chain management: A case study of a multi-tier transparency approach for SSCM in the automotive industry," *Sustain.*, vol. 12, no. 5, pp. 1–24, 2020, doi: 10.3390/su12051814.

Smart Living, a Way for Sustainability and Culture 4.0

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Abstract

It is argued that, by 2025, cities that deploy digital applications and systems that seek urban mobility, may end up reducing transit and displacement times by up to 20% on average, gas emissions by 15%, accelerate emergency responses at average by 20%, and reduce fatalities by 10%. [8]. This is expected from cities that are smart, sustainable, dynamic and knowledge generating, linked to the new wave of technologies provided by the rise of the fourth industrial revolution, also called Industry 4.0 [6]. One of the most widespread models for the concept is the European Smart Cities [10]. In this proposal, six dimensions should be mandatory, with actions focused on public policies to result in a more intelligent urban environment. The dimensions are: Smart Governance, Smart economy, Smart living, Smart environment, Smart mobility, Smart people. After more than 10 years of the fourth industrial revolution [2], it can be said that industry 4.0 has added enormous value not only to factories, but also to a whole new way of life for human beings [1]. In this way, digital technologies can assist in the management and organization of smart city routines, thus becoming part of the city itself [9]. Residents of these types of cities need to pursue reducing energy consumption and environmental impacts, especially in large urban agglomerations. Therefore, this paper proposes to understand the current state of the literature on the topic Smart living and its impacts on the sustainable life style within the smart cities' phenomenon. As such, a literature review was carried out in the Scopus and Web of Science databases in which 51 articles were identified at the end of the filtering and analysis steps. The bibliometric analysis was performed with the help of the Vosviewer software. The main result of the bibliometric was the mapping the main authors, countries of research institutions and keywords of the portfolio. It is pointed out that the biggest link of keywords belongs to the word Smart Living, but that the main choice of the authors to approach the theme is the term Smart city. Other results consist of an analysis of the synergy of how smart people provide sustainable behaviors in smart cities and industries 4.0, thus allowing a potential to develop a sustainable culture 4.0. Thus, smart life should encompass innovations related to improving health, education and social services, as well as increasing citizen participation through e-government projects, which should have a positive effect on the environment, reduce vulnerability and improve security [7]. Cities are now beginning to support the life of a new generation of human beings who are interconnected with the internet and with the intelligent thinking of 4.0 compared to what it was 20 years ago in the advent of the modern internet [4]. Smart cities have the potential to allow the reduction of impacts to the environment and an improvement in sustainable policies and practices such as recycling, circular economy and encourage the use of renewable energy in architectural models of homes and cities. In addition, smart living is based on people's accessibility, integration with 4.0 technologies, digital inclusion, maximum benefit of cities [5]. The main implications of this article are that, in a postcovid-19 world, smart living models may be able to complement people's education 4.0 and this can become a new intersection in the education approach theme about industries 4.0, sustainability and smart cities 4.0.

Keywords: Smart cities, Smart living, Industry 4.0

References

[1] Kaluarachchi. Y. Implementing Data-Driven Smart City Applications for Future Cities. Smart Cities. V 5, p. 455–474, 2022

[2] M. M. Chiampi and L. L. Zilberti, "Induction of electric field in human bodies moving near MRI: An efficient BEM computational procedure," *IEEE Trans. Biomed. Eng.*, vol. 58, no. 10, pp. 2787–2793, Oct. 2011, doi: 10.1109/TBME.2011.2158315.

[3] Liao, Y. and Deschamps, F. and Loures, E. F. R. and Ramos, L. F. P.. Past, present and future of Industry 4.0 - a systematic literature review and research agenda proposal. International Journal of Production Research, 2017.

[4] Fialová, J. and Bamwesigye, D. and Lukaszkiewicz, J. and Antoszkiewicz, B, T. Smart Cities Landscape and Urban Planning for Sustainability in Brno City. Land. 10, pp. 870, 2021.

[5] HAN, M. J., N. AND KIM, M., J. A critical review of the smart city in relation to citizen adoption towards sustainable smart living. Habitat International V. 103. 2021.

[6] Alqahtani. F. K. and Qasaby. A. R. E. and Abotaleb. I. S., Urban Development and Sustainable Utilization: Challenges and Solution. Sustainability. 13, 7902. 2021.

[7] Appio, F.P., Martini, A., Massa, S., Testa, S.,. Collaborative network of firms: antecedents and state-of-the-art properties. International Journal of Production Research. V. 55, pp. 211–2134, 2017.

[8] Mackinsey&Company, Smart cities: Digital solutions for a more livable future, 2018.

[9] Picon, A. Aprendendo com a utopia. Journal of Architeture Education. v. 67, n. 1, pp. 17–23, 2013.

[10] Tuwien - Technische Universität Wien. European Smart Cities 4.0. 2015.

Mobi2verde: A Sustainable Urban Mobility Proposal to Serve Public Network Students in Brazil

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Abstract

Urban mobility is an issue that impacts the quality of life of the population in large urban centers, and when the issue of sustainability is added the complexity of the problem increases involving more boundary variables [1][2]. Because it is a multidisciplinary theme, the issue requires a rigorous and integrated study of the requirements of the mobility system, which led the research group in Metrology - ITM, from the Federal Institute of Education of Alagoas - Brazil, to develop a proposal for sustainable urban mobility in order to meet the needs of vocational education students.

The scientific methodology was adopted with the initial hypothesis of the possibility of improving urban mobility in order to supply the commuting needs of vocational education students in Brazil through the use of electric bicycles.

The first step was to conduct a social survey to delineate the most critical aspects in the transfer of students to the educational institution.

The result allowed the survey of functional requirements needed for a mobility system for the city of Maceió, besides confirming the use of electric electric bicycles as a possible solution.

In Brazil the price for the final consumer of this mode of transportation is still expensive, so a market research on the availability of products for electric propulsion in the national market was conducted in order to design a bicycle with affordable prices for students.

The project, named MoobiVerde™, was contemplated in the 2018-2019 PIBIC (PIBIC modality) and the prototype of an electric bicycle was produced and named "2MOOVE™ Bicycle".

This prototype used conventional bicycle parts such as ratchets, bearings, chains to design a mechanical coupling system of a permanent magnet DC electric motor with 250W power operating at 36 V. This result generated the proposal of a kit to convert conventional bicycles into electric bicycles from low cost conventional parts, with an autonomy of 60km per charge.

The second moment of this work was the renewal of the PIBIC-2019-2020 project, which enabled the development of embedded electronic systems and also the realization of operation tests, autonomy, recharge and travel times within the urban perimeter of the city of Maceió in Alagoas-Brazil.

The use of telemetry techniques based on microprocessor platforms like Arduino and Espressif, made it possible to collect data in real time during the use of the prototype, which allowed proving that electric propulsion of less than 350W meets the needs of mobility in flatter urban centers, with altitude variation within the range of 50 meters and displacement distances in the range of 40 km [3][4].

This electronic system determines the bicycle's geographic position, allows it to control the use lock, the bicycle's electrical parameters, and the user's biological signals. Research on this mass of data is generating new work involving the aspect of health, physical fitness and the use of the electric bicycle as aerobic exercise.

The third stage of this work was the design of a business model for shared use of electric bicycles, managed automatically using a smartphone application.

This shared use model, called Mobi2Moove, allows the sharing of the same bicycle between students via smartphone. Thus, a mobile phone application was developed and tested to validate the shared use business model.

This application allows locating the bike, checking its state of charge and use, unlocking the bike for use, and collecting data via GPRS/GSM communication network, centralizing the data in a file server.

Another important aspect in the development of this work is the energy strategy used for the electric bicycle recharging system. Developing a modular system for recharging the bicycle culminated in the Eletroposto project, which is the current stage of this proposal [4][5].

The implementation of the first recharge module has the characteristic of serving as an information and business service center, integrating intelligent energy management, photovoltaic microgeneration system, energy storage system, sale of food products, urban surveillance, digital access point, and urban shelter, being conceived in the form of attachable modules allowing to adjust the number of recharge points and generation capacity, according to the needs of each geographical point within the model.

It is important to highlight the main results obtained so far, they are: A prototype bicycle with electric propulsion using nationalized components worth less than 1. A prototype bicycle with electric propulsion using nationalized components valued at less than 170 Euros, with 280W of power and autonomy of 30Km/charge, a model of a kit to convert common bicycles into electric ones using nationalized components, a totem for recharging sealed lead-acid batteries 12V/12A/h, an ESP-32 microprocessor based embedded module with GSM/GPRS connection for geographic reference of position and instantaneous speed, which integrates with a smartphone application, and the model of an electric station for recharging electric vehicles, notebooks, and smartphones.

Currently an effort is being undertaken to improve the power management system on the bicycle during use. Microprocessors are being tested to implement intelligent algorithms for current control at the moment of acceleration, proportional to the cyclist's effort on the bike pedal.

Despite these prototypes have served as validation for the developed models, a greater effort is needed to achieve the dissemination of this model in the Campi of the Federal Institute of Alagoas, in this sense a website is being designed to disseminate the information to reproduce the prototypes and disseminate the results achieved.

Keywords: Urban Mobility, Sustainable, Prototype.

References

[1] PLUME – Synthesis Report on Urban Sustainability and its Appraisal, PLUME- Planning for Urban Mobility in Europe.- 2003.

[2] SOUZA L.C.L, RAMOS R.A.R., SILVA A.N.R,MENDES J.F.G. Cidades Sustentáveis : Um desafio comum para Brasil e Portugal, III ENCS, São Carlos, São Paulo – 2003.

[3] CAPELAS , Buno; Tozetto, Claudia; Lima, Mariana: Startup de bicicletas Yellow é a nova aposta dos milionários da 99. Estadão, 2018. Disponível em:<encurtador.com.br/axDNP>. Acesso em:10,06,2020.

[4] GAZOLI, Jonas Rafael/VILLALVA, Marcelo Gradella. Energia Solar Fotovoltaica - Conceitos e Aplicações - Sistemas Isolados e Conectados à Rede. S. Paulo: Érica, 2012.

[5] MARICATO, Ermínia (org). Cadernos MCidades – Mobilidade Urbana. Ministério das Cidades – 2004.

Reduction of GHG Emissions from Electric Mobility Penetration: a Study Case in Sal Island

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Abstract

Electrification of the transport sector in Cape Verde, followed by the construction of a flexible and dynamic national charging infrastructure, turns to be one of the best technological developments and economical advances in the country. Cape Verde has a strong dependence from the fossil fuels to support the current transport sector and to produce electric energy. In fact, only 18,3 % of Cape Verde's electricity is obtained from renewable sources [1], which results in a deep impact on the country's financial resources and on the environment, due to the inherent greenhouse gas (GHG) emissions.

Through the creation and implementation of the National Program for Energy Sustainability and the Master Plan for the Electricity Sector, along with other instruments, Cape Verde's Government plans to accelerate the energy transition aiming at reaching 30% of electricity production from renewable sources in 2025, 50% in 2030 and 100% in 2040 [2]. Within the energy transition scenario, the effort is to promote a low carbon economy, while strengthening the country's economic competitiveness, with the Government having the role of promoter, facilitator, partner and regulator of a market for the production and energy supply. This transition takes place in alignment with the Sustainable Development Goals 7 – Clean and affordable energy, as well as the country's main commitments on climate change [2]. From the total fossil fuels imported in 2020, the major parcel was consumed by the transport sector (41,83%) assuming just the use of diesel and gasoline, followed by the production of electricity, in a total of 38,69%, as presented in Figure 1.

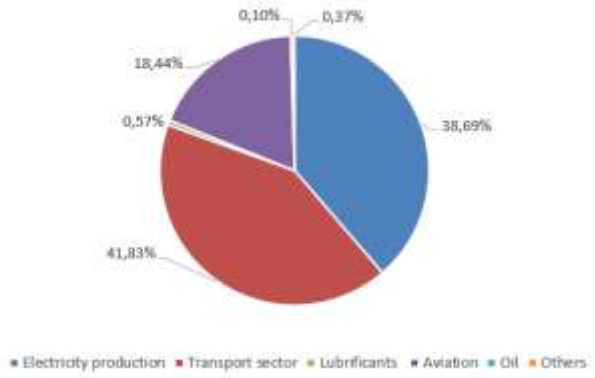

Figure 1 - Fossil fuel's consumption by sector [3].

Despite Cape Verde has lower emissions when compared with other countries, with 0,99 tCO_2eq per capita [4, 5], there is still a compromise aiming at reducing the GHG emissions further and increasing the penetration of renewable energy, as part of honouring the Paris Agreement and the United Nations Framework on Climate Change. Another strategy to decrease the consumption of fossil fuels and GHG emissions in the transport sector is to implement policies able to accelerate the deployment of the electric mobility in the country. Those policies aim at, by 2026, 15% of the new acquisitions of the national fleet consisting of electric vehicles, as well as the penetration of 30% of electric vehicles in the public administration, managers and members of the Government. In the same way, an effort is being made to proportionally increase the electric vehicle charging infrastructures [6].

In the context above, this work presents a study case aiming to analyse the electric mobility's development in

Cape Verde, and the amount of GHG emissions that is possible to avoid with the usage of electric vehicles (EV). The study case consists in the analysis of the fleet of a company located in Sal Island that has been replacing the conventional vehicles using internal combustion engines (ICE). Up to now, the fleet includes six electric vehicles in detriment of 6 diesel ICE vehicles for the daily activities. The performed analysis exploits the GHG emissions avoided by the fleet changes, by using the software COPERT 5 [7], a EU standard vehicle emissions calculator that uses vehicle population, mileage, speed and emissions and energy consumption for a specific country or region as inputs to generate results.

The performed analysis considers two scenarios. The first one is based in the EV's charging from 100% renewable sources which results in a total of 30 tons of GHG emissions saved. The second one, exploits the EV's charging from the utility grid, from which the electric energy is not zero emissions, corresponding to a decrease of 30% of the total GHG emissions, which results in a real saving of 21 tons, due to the inherent pollution from the electricity production in the Island.

Keywords: Electric Mobility, Renewable Energy, Greenhouse Gas Emissions, Transport Sector.

References

[1] Ministério de Indústrias, Comércio e Energia "Energias Renováveis Cabo Verde."Governo de Cabo Verde. [Online]. Available: https://www.energiasrenovaveis.cv/. [Acessed: Sept. 29, 2021].

[2] Ministério de Indústrias, Comércio e Energia, "Plano Nacional para o Sector Energético."Governo de Cabo Verde. [Online]. Available: https://www.portalenergia.cv/pnse. [Acessed: May. 15, 2022].

[3] ENACOL, "Relatório e Contas 2020".[Online]. Available: https://www.enacol.cv/wp-content/uploads/2022/01/relatorio_contas_2020.pdf. [Acessed: May. 3, 2022]

[4] Pedro Reis, "O que deve saber sobre o autoconsumo por painéis solares fotovoltaicos". Portal energia - Energias renováveis. [Online]. Available: https://www.portal-energia.com/deve-saber-autoconsumo-paineis-solares-fotovoltaicos/.[Acessed: Jun. 15, 2022]

[5] Governo de Cabo Verde, Conselho de Ministros. "*Resolução nº107/2021"*. Imprensa Nacional de Cabo Verde, SA. 2021, p. 32.

[6] Ministério de Indústrias, Comércio e Energia, "*Resolução n.º 13/2019. Carta de Política de Mobilidade Elétrica*." Imprensa Nacional de Cabo Verde, SA. 2019, p.11.

[7] Emisia, "Copert - The industry standard emissions calculator." Emisia Conscious of Transport's Impact. [Online]. Available: https://www.emisia.com/utilities/copert/. [Acessed Jun. 05, 2022].