CONECT 2024

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RIGA TECHNICAL UNIVERSITY

XVII International Scientific Conference of Environmental and Climate Technologies

BOOK OF ABSTRACTS

15–17 May 2024 | Riga, Latvia

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XVII International Scientific Conference of
Environmental and Climate Technologies

BOOK OF ABSTRACTS

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CONECT 2024

XVII International Scientific Conference of Environmental and Climate Technologies

Welcome to CONECT 2024 – an international scientific conference that has been held since 2008 and annually brings together scientists, researchers, PhD students and professionals from all over the world.

The conference`s purpose is to acquaint with achievements in the area of energy systems and environmental engineering and to give an opportunity to exchange and share experiences and publish research results.

The three-day event will feature an impressive line-up of speakers from around the world in Plenary and Panel sessions on the following topics:

- Bioresources
- Biotechnologies
- District Heating
- Energy Efficiency
- Environmental and Energy Policies and Frameworks
- Low Carbon Development and Bioeconomy
- Renewable Energy Technologies
- Sustainability and Resilience

The conference papers are published in the international scientific journal "Environmental and Climate Technologies" (ISSN: 2255-8837) indexed in SCOPUS and Web of Science.

The conference is organized by the Institute of Energy Systems and Environment (IESE) of Riga Technical University

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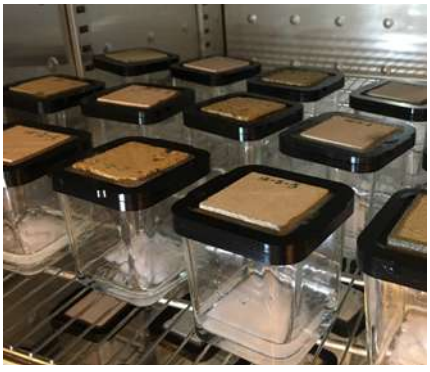

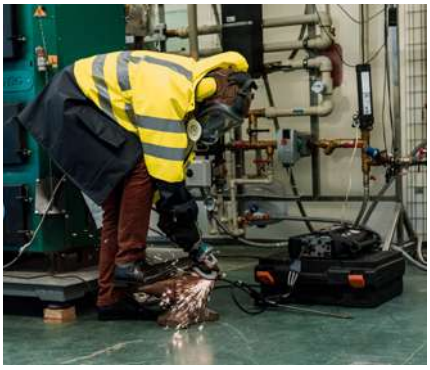

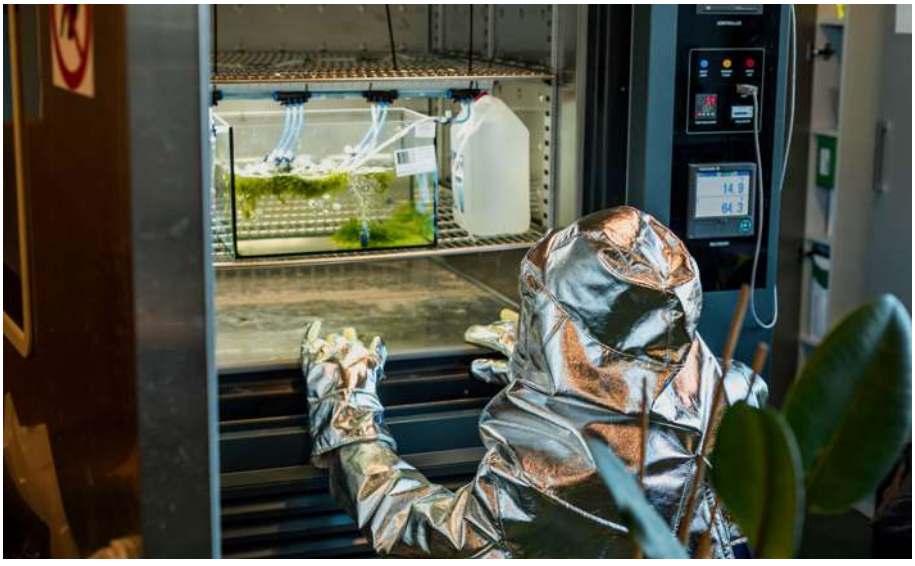

JOURNAL OF ENVIRONMENTAL AND CLIMATE TECHNOLOGIES

The Journal of Environmental and Climate Technologies, published by RTU IESE, is an international scientific journal that offers global exposure for original research and innovations.

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- Cleaner Production and Industrial Symbiosis,
- Ecodesign and Life Cycle Assessment,
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We express gratitude to the sponsors for their support towards this year's conference.

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The accommodation of CONECT 2024 participants is taken care of by the Mogotel hotel group.

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ENERGY EFFICIENCY, ENERGY SYSTEMS (DISTRICT HEATING)

https://doi.org/10.7250/CONECT.2024.001

ELECTRIC VEHICLE CHARGING INFRASTRUCTURE STUDY FOR APARTMENT BUILDINGS

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Abstract – Changes in the engine type of cars aimed at climate goals also have an impact on the habit of electricity consumption at home. Charging electric cars from the residential grid also increases the total electricity consumption of the residential building. If all apartment owners in an apartment building charge their electric car at the same time, it may create a situation where the main protection of the apartment building is activated. The purpose of this research is to identify possible options to avoid this problem, based on various real-life data. For example, adding an energy storage to the electrical system of an apartment building is seen as one solution. Also supplement of an energy management software to the electrical and battery bank system enables residents to schedule and prioritize their electric car charging times to avoid simultaneous high-demand periods. This system can also be used to optimize electricity distribution and consumption in apartment buildings under volatile electricity price conditions.

Keywords – Energy Management; energy storage; renewable energy; smart grid

https://doi.org/10.7250/CONECT.2024.002

ROBUST DESIGN OF 5TH GENERATION DISTRICT HEATING AND COOLING (5GDHC) SYSTEMS WITH SEASONAL THERMAL ENERGY STORAGE VIA GIS ASSESSMENT

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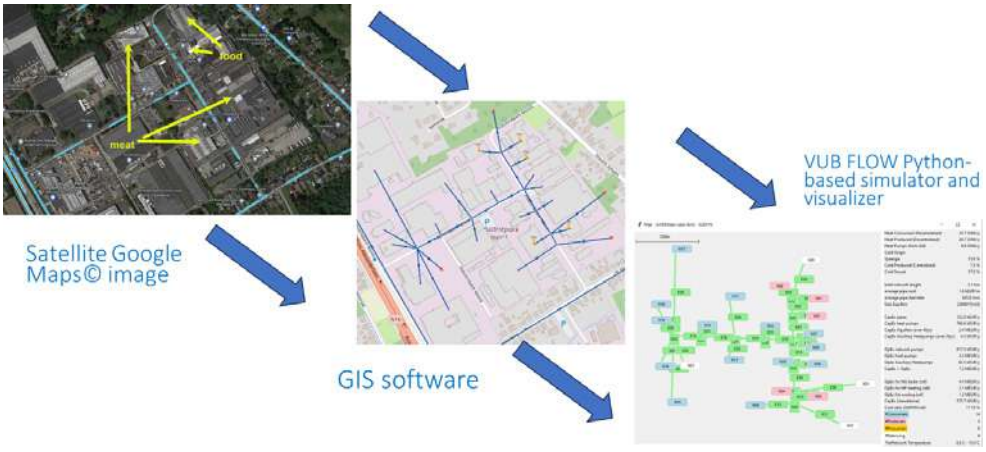
Abstract – This research addresses the need for a method to compare waste heat potential and recovery in 5th Generation District Heating and Cooling (5GDHC) systems. Prosumer buildings, known for enhancing flexibility, are analysed using Geographic Information Systems (GIS) and image vectorization to evaluate 5GDHC systems. The study predicts the amount of waste heat available with an R2 of 0.96, utilizing Chaikin's algorithm to refine thermal images for automatic recognition of the sources of waste heat. Emphasis is placed on the absence of a method for asset design in 5GDHC, with considerations for annual energy calculations, radial network connections, and energy shares among building types. Recommendations for building connecting in Belgium are proposed, favouring 'B'/'C'-labelled buildings. The research explores the impact of building design on heating and suggests energy savings through regulation strategy changes. Dynamic models for heat pumps aim to reduce errors and emissions. The study connects energy indicators and GIS software, contributing to a top-down design approach in 5GDHC systems. The overall goal is to contribute to decarbonization and reduce CO_2 emissions in the energy sector.

Keywords – District energy systems; Geographic Information Systems (GIS); waste heat; renewable energy integration; prosumer; modelling



A first guess converted into a GIS image and then to a graph-theory-driven simulated location

ACKNOWLEDGEMENT

This project received funding from VLAIO in Belgium, ICON project OPTIMESH (VLAFLX7, https://researchportal.vub.be/en/projects/icon-project-optimesh & FLUX50 ICON Project Collaboration Agreement – HBC.2021.0395).

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MAIN PRINCIPLES AND SOLUTIONS FOR ACCELERATION OF ENERGY EFFICIENT RENOVATION IN LATVIA

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Abstract – The European Renovation Wave aims to at least double the annual energy renovation rate by 2030, especially promoting deep renovation. In order to achieve this goal, EU member states need to overcome the existing obstacles in the whole chain of the building renovation process by using certain policy measures and finance instruments. According to the Ministry of Economics of Latvia, the current necessity is to renovate around 26 thousand multi-apartment buildings. Therefore, not only the problem of the lack of additional financing should be solved but also the pace of implementation should be significantly increased. This study starts with an overview of the main obstacles of the building renovation in Latvia and gives an insight into the main challenges in the achievement of the goal. The study includes the review of existing support programmes and financing schemes, designed to improve the energy efficiency of multi-apartment buildings in Latvia. Moreover, the study analyses the existing support mechanisms in Latvia, and reviews different policy measures for regulatory requirements, fiscal and economic incentives and information campaigns in Europe. In addition, the study proposes an assessment of the availability of financial support for the low-income households, and analyses energy poverty solving tools. As a result, the study defines basic principles and examines the solutions for energy efficient renovation in Latvia – including tax incentives, regulatory framework, development of financial schemes and models for acceleration of building renovation. The solutions have been evaluated considering country specific economic, technical, and social aspects, and defined as a set of recommendations for decision makers.

Keywords – Buildings; energy efficiency; financial support; renovation; recommendations

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NUMERICAL ANALYSIS OF HARMFUL ENVIRONMENTAL IMPACT OF ACCIDENTAL EXPLOSION AT A HYDROGEN FILLING STATION

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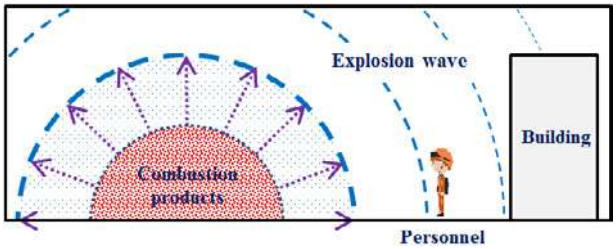
Abstract – Hydrogen is a very important and valuable source of energy for modern vehicles. However, it is extremely explosive. An accidental failure of compressed hydrogen storage equipment at a filling station can lead to the release of hydrogen into the atmosphere, the formation of a hydrogen-air mixture, and its explosion, and the blast wave can lead to destruction and human casualties. The purpose of this study is to evaluate numerically the harmful consequences of a hydrogen-air mixture accidental explosion at a vehicle hydrogen filling station in order to suggest measures to protect the environment from blast wave overpressure. The physical process of the explosion, which takes place after the hydrogen gas release into the air due to the accidental destruction of a number of high-pressure storage cylinders, is considered. The blast pressure wave moves in all directions from the epicenter of the accident, gradually losing its intensity and having a negative shock impact on the service personnel of the filling station and the structures of the surrounding buildings. The scale of the accident depends on the number of destroyed cylinders, which determines the size of the hydrogen-air cloud and the power of the explosion. The degree of negative consequences for the environment depends on the maximum overpressure in the blast wave front. Numerical obtaining of spatial pressure distributions in the area of the accident based on a hydrogen explosion mathematical modelling makes it possible to separate zones that are dangerous to human health and building structures strength. The direct problem of gas dynamics of combustion products of a hemispherical cloud of a stoichiometric hydrogen-air mixture in the surface layer of the atmosphere is considered. The mathematical model of an instantaneous hydrogen explosion takes into account the threedimensional and non-stationary nature of the propagation of the explosion wave, the compressibility of the gas flow, the complex terrain, the shape and initial concentration of the cloud of hydrogen combustion products, and their thermodynamic parameters. The model makes it possible to obtain threedimensional fields of maximum overpressure, which are the basis for deterministic assessment of the consequences of an accident for human health and the integrity of structures in the area of the explosion. The presented computer technology allows security experts to identify potentially dangerous zones by means of mathematical modelling, and recommend effective protective measures to mitigate or even eliminate the negative consequences of the blast wave environmental impact.

Keywords – Gas mixture explosion; pressure wave; maximum overpressure; human health impact degree; structure destruction grade



The scheme of the blast wave propagation in the area of the accident.

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COMPARING NUMERICAL AND ANALYTICAL METHODS FOR HEAT LOSS DETERMINATION OF DISTRICT HEATING SYSTEMS

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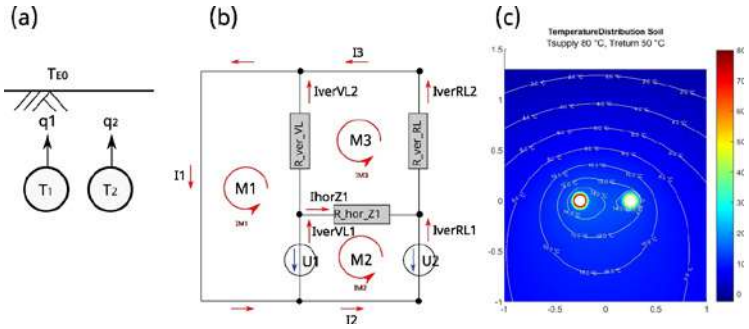
Abstract – Energy efficiency assessment considers the heat losses in district heating systems. For instance, life cycle assessments of such engineering structures require knowledge of the heat losses during their use phase. Therefore, it is essential to have the most accurate knowledge of the heat losses of a district heating system. In this study, three different methods for the determination of specific heat losses for buried preinsulated steel pipes are compared. The first method involves an analytical calculation in accordance with EN 13941, while the second utilizes an equivalent circuit approach. The third method employs finite element analysis. The objective was to evaluate the accuracy of the methods, the achievable range of results, and the effort required to solve the respective calculation algorithms. Therefore, typical 2-dimensional cross sections including different pipe diameters were selected. In situ measurements were not part of this study. Consequently, the analysis centres on the deviation between the methods. All three methods determine the heat loss in both the supply and return pipes. While the analytical calculation method cannot determine temperatures in the soil, the equivalent circuit method can handle more complex tasks and gives detailed results at predefined points in the model. With the finite element method, a high degree of detail can be achieved, but the requirements for solving the algorithms increase. An emerging trend in district heating involves reducing operational temperatures in both new and existing networks. This will change the relation between heat losses and heat delivered to the customers. Subsequently, an increasing interest in the actual heat losses and the precision of calculation is expected within this development. Therefore, it remains essential to evaluate the performance of different models.

Keywords – Equivalent Circuit Method; district heating; heat losses; finite element analysis



(a) Analytical method, (b) Equivalent circuit method, (c) Finite Element Analysis.

ACKNOWLEDGEMENT

This work is a result of cooperative discussions at HafenCity University in the research projects EnEff:URBAN TURN, SAM-FW, and EnEff:NETZREGELUNG. These projects are nationally funded by the Federal Ministry for Economic Affairs and Climate Action. The funding is gratefully acknowledged by the authors.

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FUTURE OF DISTRICT HEATING SYSTEMS – INVESTIGATION OF VARIOUS TECHNOLOGIES IN THE DANISH CONTEXT

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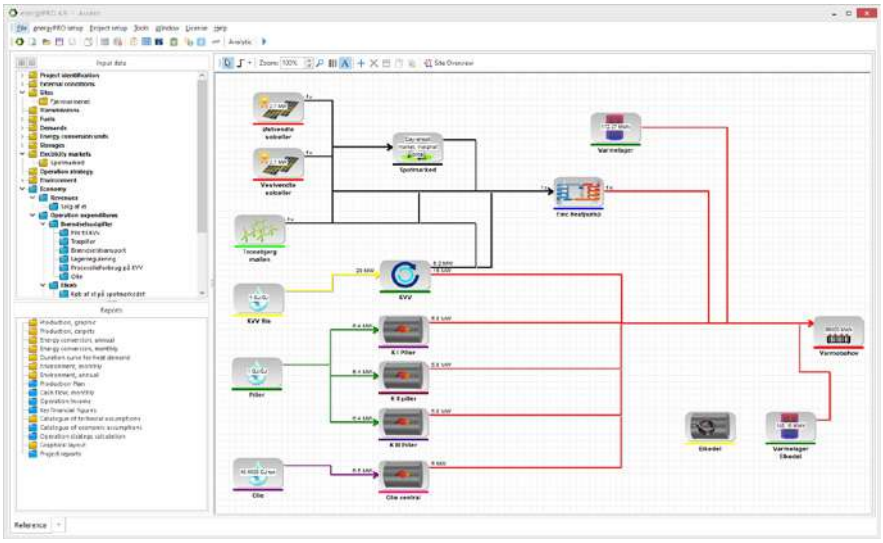
Abstract – In response to the urgent need for decarbonization, district heating (DH) systems must explore emission-reducing investments that simultaneously lower operational costs of the plant. The recent years with wildly fluctuating gas and electricity prices put even more emphasis on finding the optimal combination of generation units for DH systems. This article aims at investigating which of the available technologies are the future of district heating. Solar collectors, photovoltaics (PV) and wind turbines and their combinations with other technologies are considered. The analysis is done based on Assens District Heating located in Funen, Denmark, where the annual heat production is approximately 96 000 MWh. The plant has already invested in an East-West oriented PV plant and a heat pump. However, for the purpose of this paper, an assumption is made that this investment can be redone based on the present investment costs in Denmark. The analysis is made in the energy system analysis tool energyPRO, where different combinations of technologies are analyzed. The study investigates the operational and investments costs, looking into the influence on Net Heat Production Cost (NHPC) and quantifying the investment yearly benefit. The results demonstrate profitability and feasibility of integrating renewable energy resources into district heating systems within the Danish context. The ambition is to showcase the possibilities and provide decision makers with insight into robust investments in renewable energy systems. Furthermore, by highlighting the success and potential of renewable energy integration in district heating systems in Denmark, this study aims to inspire further research and innovation in the field in other European countries, where the DH systems are primarily based on fossil fuels.

Keywords – District Heating (DH); Net Heat Production Cost (NHPC); Renewable Energy; Photovoltaics (PV); Solar Collectors; Wind Turbines



Model of the Assens District Heating System in EnergyPRO.

https://doi.org/10.7250/CONECT.2024.007

DESIGN AND PERFORMANCE ASSESSMENT OF DISTRICT HEATING SYSTEMS IN THE LATVIAN REGION

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Abstract – The energy consumed by buildings for air conditioning accounts for a large percentage of global energy consumption. To promote efficiency and sustainability, the scientific community is making great effort to develop renewable technologies. A well-known but unfortunately underestimated solution is the development of centralized heating and cooling systems that consistently reduce energy consumption. The work proposes a comparison between three heating configurations covering the demand of a settlement in the Latvian region: 1) centralized district heating (DH) system; 2) 5th generation district heating & cooling (5GDHC) system and 3) individual home heating (HH) systems. Thermal and electrical loads are evaluated by transient simulations of a residential area with 80 buildings for the Riga climate and compared with the same settlement in a Mediterranean region (Milan, IT). The energy plants are based on different technologies: combined heat and power (CHP) plants, gas-fired boilers, and domestic heat pumps. The analysis includes the option of power exchange with the national grid. A transient numerical model has been developed for each solution. Every component is modelled according to performance maps provided by the manufacturers, allowing an accurate simulation in both design and off-design operating conditions. The study covers energy, economic and environmental aspects. The result of the simulation highlights the large difference between the two locations, not only in terms of annual load but also in terms of load distribution. On an annual basis, the Latvian residential complex requires almost twice as much energy as the Italian one. The thermal losses in the district systems are 4.21 % in Milan solution and 5.65 % in Riga. The district heating system coupled with heat pump represents the best layout in terms of primary energy consumption in both locations, with energy savings of 50 % compared to other solutions. The use of 5GDHC is a good compromise that could increase the use of renewable energy. The adoption of cogeneration plant is a good choice in case of centralized district system that allows the installation of high efficiency genset. On the contrary, for small application as residential, the installation of cogeneration system results expensive and the conversion efficiency does not justify the installation.

Keywords – District heating; energy efficiency; transient simulation

https://doi.org/10.7250/CONECT.2024.008

USE OF AN ABSORPTION HEAT PUMP TO LIFT THE DISTRICT COOLING WASTE HEAT TEMPERATURE FOR THE DISTRICT HEATING SUPPLY IN TALLINN: A TECHNICAL AND ECONOMIC ANALYSIS

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Abstract – Absorption heat pumps can lift a lower temperature waste heat source to a higher temperature useful output. In that process, it uses less electricity as an input compared to heat pumps with electrical compressors. Therefore, in some cases, it can be used to lift a lower temperature waste heat source to a higher temperature useful output with less electricity consumption. Absorption heat pumps are not very widely spread in district heating, mostly because there are not many suitable waste heat sources or conditions needed to run them. Tallinn has a district heating system with an annual generation of more than 2 TWh and a goal to make it an entirely carbon neutral district heating system by 2030. Tallinn has also started to develop a district cooling network, and by the end of 2023, the installed capacity was about 6 MW. District cooling capacity is estimated to grow to around 100 MW in 2030. This paper investigates different types of absorption heat pumps and the possibilities of integrating an absorption heat pump to a district cooling plant with the purpose of using waste heat from the cooling plant for renewable heat generation, that can be used in district heating. Different technical aspects are examined to find a suitable production solution and are presented as results. From an economical point of view, the cost of heat to cover peaks with an absorption heat pump is calculated. The effect of reducing fossil fuel use in the Tallinn district heating network with an absorption heat pump is estimated.

Keywords – Coupling district heating and cooling; energy modelling; sustainable district energy; power to heat

ACKNOWLEDGEMENT

AS Utilitas Tallinn, district heating and cooling operator in Tallinn.

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A SHOWCASE FOR RESILIENT AND SUSTAINABLE DISTRICT HEATING IN DENMARK

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Abstract – This presentation gives a description of the Danish district heating company, Hvide Sande District Heating, which has become independent of fossil fuels by using wind and solar energy. This has resulted in lower consumer heating prices in a time when other fossil fueled district heating plants are raising their heating prices due to higher fossil fuel prices. Besides participating in the Day-ahead market it also participates in the balancing markets. Hvide Sande is a small fishing town. The district heating plant provides heat to 1 700 consumers. From being a natural gas fired Combined Heat and Power plant, it has in recent years become more resilient by investing in a solar collector, wind turbines, a heat pump, an electrical boiler as well as more large thermal storages, and is now independent of natural gas. The two thermal storages of 2 000 m^3 and 1 200 m^3, respectively, can store around 200 MW hheat, which allows flexible marketbased productions of the different production units. The heat delivered to consumers can thus be produced many hours or days before delivery. Even in the Day-ahead market, the marketbased productions are a challenge to plan. Because of the large thermal storages, the manager must look more days ahead as well as consider the heat amount in the thermal storages when deciding the hourly bids for tomorrow. Biddings are based on forecasts more days ahead of wind velocity, solar radiation, ambient temperatures, and Day-ahead prices. Besides participating in the Day-ahead market it also participates in the balancing markets. However, to take advantage across more electricity markets of this flexibility, a vast digitalization of the plant using advanced bidding methods has been required. This presentation illustrates examples of the daily earnings the plant has had participating across more electricity markets. It is also important that the manager maintains a digital twin of the plant. The digital twin of the plant will in this presentation be used for simulating the resilience of the plant against large changes in electricity prices and fuel prices.

Keywords – District Deating (DH); digital twin; electricity markets; independent of fossil fuels; resilience; using wind and solar energy

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ATTRACTING CUSTOMERS TO DISTRICT HEAT SUPPLY: THE CASE OF RIGA

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Abstract – District heating is important in achieving future climate goals. Possibilities of using waste heat from different sources, e.g. subways, hospitals, shops, data centers, rivers are often discussed. Many district heating companies face the challenge of sufficient coverage of connected consumers in a city or region. To expand the operating area, companies should initially attract objects which are close to heat networks to lower the connection costs. The research question is how to attract existing buildings under construction to the district heating system. The present work uses system dynamics modeling for studying the possibilities of the Riga district heat supply company to increase consumer network. Modeling is based on historical data of residential buildings. The results show that old buildings choose to connect to the district heat supply when these are being renovated, or the individual heat supply equipment is out of order. The older the buildings, the more likely these will be connected to the district heating, however, this decision may take at least 70 years. Renovation increases the probability of connection to the district heating, so the impact of subsidies for renovation is important. Regulation that requires connection to the district heating as a priority choice in case of renovation is also important.

Keywords – Buildings; energy efficiency; district heating; system dynamics

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ASSESSMENT OF THE POTENTIAL FOR INCREASING THE ENERGY EFFICIENCY IN THE COOLING SECTOR

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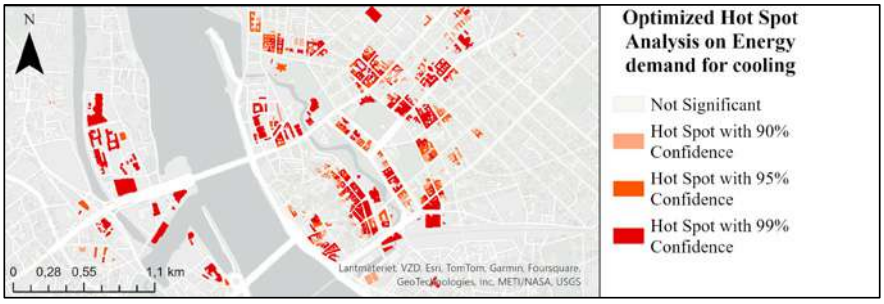
Abstract – Cooling supply to ensure the indoor microclimate is becoming more important as global average air temperatures rise. With growing societal demands for higher thermal comfort and increasing individual cooling solutions in the building sector, global energy consumption for cooling is increasing accordingly. Scientific literature and studies estimate that the demand for cooling energy will have a significant impact on global energy demand in the future. In compliance with the European Union goal of achieving climate neutrality by 2050, it is essential to find solutions for reducing energy consumption in the building sector, which is already among the largest energy consumers and greenhouse gas emission producers. Replacing individual cooling solutions with district cooling in urban areas, where higher energy density can be reached, is one of the solutions for decarbonizing the building sector. To spatially assess the feasibility of district cooling in certain areas, energy demand mapping can be performed. Within this research mapping is carried out using a geographical information system (GIS) tool. The purpose of the mapping is to identify the places in the city of Riga with the highest district cooling potential. Spatial assessment using a GIS tool can be done in different ways – mostly it depends on the available data. The spatial data (buildings) of the cadastral information system and additional detailed information about buildings were obtained from the Latvian open data portal. Information on the type of use of the building, indoor area and the age of building was attached to each building on the map. Then, building energy certificate data containing information on specific energy consumption for cooling (kWh/m^2 per year) was obtained from the same portal. By processing the data of energy certificates of buildings, excluding outliers, a specific index was obtained for different types of buildings. For the residential sector, the age of the building is also used. Using cadastral data on the indoor area of buildings and the type of building use, the theoretical cooling demand in Riga is calculated and results are quantified and displayed visually. By visualizing the results with the GIS tool, hot spots with the highest cooling energy demand were detected. Results can be further used to calculate the technical and economic justification for the district cooling solutions in specific areas as well as assess the energy efficiency that would be provided by implementation of district cooling solutions.

Keywords – Buildings; climate; district cooling; energy demand; GIS; mapping



Statistically significant hot spots with higher density of energy demand for cooling in the part of city of Riga.

https://doi.org/10.7250/CONECT.2024.012

ARE BSR MUNICIPALITIES ON TRACK FOR ENERGY TRANSITION?

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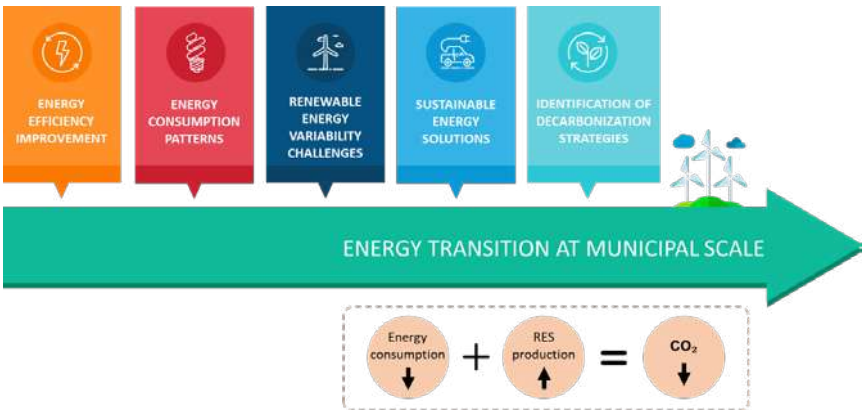
Abstract – Climate neutrality targets and the growing decentralization of energy systems have substantially increased the role of municipalities in global energy transition. However, global shifts and national government demands have often left local public authorities unprepared to face numerous challenges related to local space planning, cost-effective integration, and decarbonization of electricity, heating, industry, and mobility. Therefore, there is a need to investigate the current state of municipal energy transition and analyze how municipalities face climate neutrality target achievement. This study conducts an integrated energy sustainability assessment to investigate the progress of the energy transition in six municipalities in the Baltic Sea region. A benchmarking approach is applied to compare the different levels of energy efficiency and decarbonization in the municipalities. The study reveals different energy consumption patterns of municipal buildings, which are influenced by various factors such as the type of building (educational, office, social facilities, etc.), the heat source (district heating or individual local heat source) and the energy efficiency management practices applied. In addition, a different trend in the installation of renewable energy capacity can be observed in municipalities in Latvia, Lithuania, Poland and Sweden. The study analyzes the overall gap between the production and consumption of renewable energy to determine the storage potential and the role in the local energy transitions. The findings of this study highlight the key cornerstones in the current state of municipal energy transition, setting a foundation for better and more effective energy policy planning at national and local scales.

Keywords – Benchmarking; energy efficiency; energy policy; energy storage; energy sustainability; energy transition; municipality; renewable energy sources (RES)



Municipality energy sustainability analysis segments integrated in the assessment.

ACKNOWLEDGEMENT

This research is funded by the Interreg Baltic Sea Region's project "Carbon driver energy equilibrium at the municipal scale (Energy Equilibrium)", Project no. #C027.

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ENERGY EFFICIENCY IMPROVEMENT FOR MANUFACTURING COMPANIES IN LATVIA

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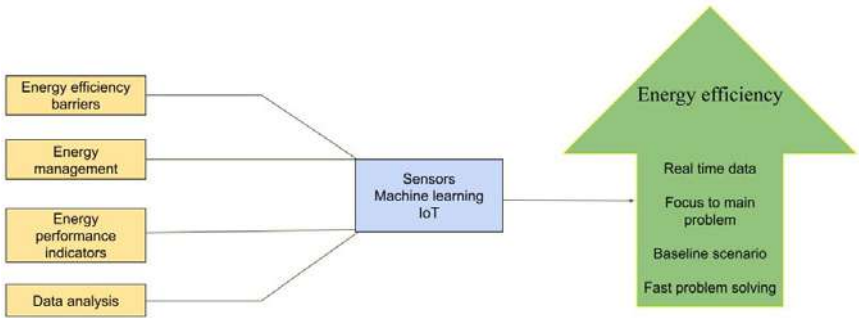
Abstract – Climate change and environmental issues are becoming more and more popular nowadays, and are causing concerns in everyone's life and beyond. One of the significant causes of climate change is energy consumption, especially in the manufacturing sector. Even though energy efficiency (EE) topic has been extensively discussed, not all EE aims are met. For the manufacturing sector, the reason is that EE is often not a top priority for the companies. Currently, the companies are also faced with another big challenge – in this digital era of rapidly developing technologies they have to adjust their practices to seize the opportunities provided by digitalization and automatization. Therefore, the aim of this research is to explore how digitization can be combined with EE to promote the resilience and increase performance of manufacturing companies, and how remote data analysis, also by using machine learning tools, can help improve EE. Literature review, content analysis, empirical data analysis and case studies from the real production companies in Latvia are used to achieve the research goals. The results section shows how digital tools and real-time monitoring help in the assessment of the current state of the business, and making decisions on changes to future operations, helping to reduce consumption and the environmental impact of production. Manufacturing companies have the potential to improve EE through digitalisation, but the manufacturing processes are complex, and Latvian companies are only slowly moving towards digitalization. Therefore, there is a strong need to examine empirical cases to gather more perspective and to find a way to implement digitalization and EE improvement across all sectors. Conclusions suggest that manufacturing companies should be encouraged to move towards a more unified energy data collection system, enabling more efficient data analysis and proposals for energy efficiency improvement.

Keywords – Energy efficiency; digitalization; improvement; manufacturing companies



Incorporating digitalization to increase energy efficiency in manufacturing companies.

https://doi.org/10.7250/CONECT.2024.014

INTEGRATING SUSTAINABLE ENERGY TECHNOLOGIES INTO DISTRICT COOLING SYSTEMS: A REVIEW OF MODELLING AND OPTIMISATION APPROACHES

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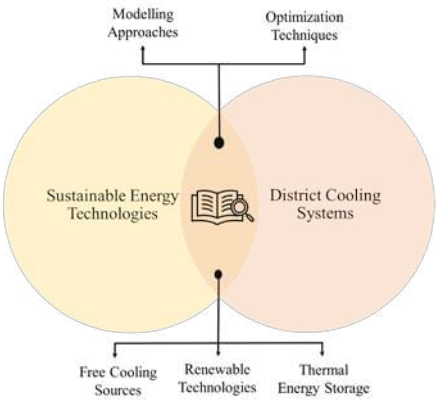
Abstract – With the rising cooling demand and prevalent energy crisis, District Cooling (DC) is evolving as one of the sustainable energy solution worldwide. As per 'EHP DHC Outlook, May 2023', the sales in DC sector reached 3 TWh, covering more than 150 European cities. The centralised nature of the DC system offers such benefits as energy efficient operations, sector coupling, peak load management. Further, the feasibility of integrating renewable technologies (e.g., solar energy), free cooling sources (e.g., seawater heatpumps) and thermal energy storage (e.g., ice slurry) is also explored. These developments make the futuristic DC system quite complex, as it involves multiple energy transformations. In this regard, utilising computation tools for decision-making has become increasingly relevant. However, choosing the appropriate approach among the existing ones in this evolving field is an important task for energy practitioners. The aim of the study is to review the modelling and optimisation approaches in the context of innovative DC systems. Data collection and analysis is based on desk-review of scientific literature published in the recent past. Firstly, various possibilities of integrating sustainable energy technologies for DC applications are explored. Then, relevant modelling and simulation approaches are studied, focussing on the similarities and limitations. Finally, different optimisation methods are examined in terms of parameters such as objective functions, control variables, solving techniques. The contribution of the study involves overview of different integration pathways, identifying the strength and weakness of modelling approaches and insights into suitability of optimisation techniques. It is expected that this study will be a reference material for performing feasibility studies as well as developing digital-twins in DC context.

Keywords – Energy Storage; energy modelling; free cooling; optimisation algorithms; sustainable cooling



Pictorial representation of main topics considered for the proposed methodology.

ACKNOWLEDGEMENT

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MEASURING THE DECARBONISATION PROGRESS OF BUILDINGS BASED ON EUROPEAN OPEN BIG DATA

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Abstract – The European Commission (EC) has established climate neutrality by 2050 as one of its objectives. To achieve this, decarbonising the building stock is crucial since buildings are responsible for 36 % of European greenhouse gas emissions. Monitoring the progress of decarbonisation is crucial to understand where we stand in terms of achieving long-term decarbonisation goals, facilitate evidence-based decision-making, promote accountability among member states (MS), and engage the public in these initiatives. However, data collection for monitoring the decarbonisation of buildings represents a challenge for MS, for which they may not be adequately prepared. To promote the collection and publication of open data, the EC has established frameworks for developing open data infrastructures within MS through various directives, offering comprehensive and well-organized information. Directives such as the Infrastructure for Spatial Information in Europe (INSPIRE), which advocates for the collection and accessibility of data in diverse topics, and the Energy Performance of Buildings Directive (EPBD), enabling the analysis of extensive information on the energy efficiency of constructed assets through the open publication of Energy Performance Certificates (EPC) databases, exemplify these efforts. However, this information often remains dispersed and narrowly focused, necessitating the integration of other data sources to extract meaningful insights. The paper delves into the benefits of georeferencing and automated cross-referencing of open data on buildings, enabling the monitoring of decarbonisation progress. To achieve this, we have developed a national-scale Urban Building Energy Model (UBEM) for Spain. This model is founded on EPCs and other open data derived from public information sources established through European directives. Additionally, we have investigated the prospect of integrating data from Digital Building Logbooks (DBL), which are emerging data repositories on buildings promoted by the EC in the forthcoming EPBD, into the UBEM to enhance the model. The study showcases significant potential in developing information on various topics, including characterising the Spanish building stock – a framework that may be extrapolated to other MS – in terms of energy performance based on location, archetype, and age. The study also focuses on estimating energy consumption and carbon dioxide emissions, monitoring the progress of renovations, evaluating the achieved energy savings, and identifying and characterising the least energy-efficient segments of the building stock.

Keywords – Building decarbonisation; Digital Building Logbook (DBL); digitisation; Urban Building Energy Model (UBEM); renovation

Acknowledgement

This work has been supported by the Ministry of Science and Innovation of Spain, grant number PID2019-104871RBC21/AEI/10.13039/501100011033 and by Gobierno de Aragón, grant number T37_23R: Built4Life Lab.

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EXPLORING THE EFFICACY OF RANDOM LINEAR PARAMETER MODELS FOR FORECASTING HEATING DEMAND IN DISTRICT HEATING NETWORKS

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Abstract – The heating and cooling sector accounts for approximately half of the global energy consumption, making it a pivotal focus for energy transition efforts. District heating and cooling networks have emerged as efficient, innovative, and dominant technologies in various regions. Accurate forecasting of heating demand within these networks is imperative for effective energy transition and responsive demand management. While existing forecasting techniques primarily concentrate on limited parameters such as ambient temperature and time of day, this paper explores the multifaceted impact of various factors, including ambient temperature, energy prices, number of consumers, building types, and solar radiation, on heating demand. Through a comprehensive study of these determinants, a robust and efficient forecasting model is developed in this research. Specifically, a novel Random Linear Parameter Model (RLPM) is introduced for hourly heating demand forecasting within district heating networks. The model's performance is assessed and compared with existing forecasting models, namely Linear Regression, ARIMA, and RLPM. A notable advantage of the Random Parameter Linear Regression model lies in its capability to recognize unobserved parameters influencing demand and account for unobserved heterogeneity, providing a robust framework for incorporating these factors into the forecasting process. This study aims to underscore the proposed approach advantages in terms of accuracy and its ability to estimate the determinants of heating load, thereby offering reliable future forecasting. The findings have the potential to significantly contribute to optimizing district heating systems by delivering more nuanced and dependable predictions of heating demand.

Keywords – Data-driven model; econometric models; energy forecasting; forecasting techniques; heating demand determinants

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TECHNO-ECONOMIC MODEL OF DISTRICT HEATING ENERGY HUB: THE CASE OF LATVIA

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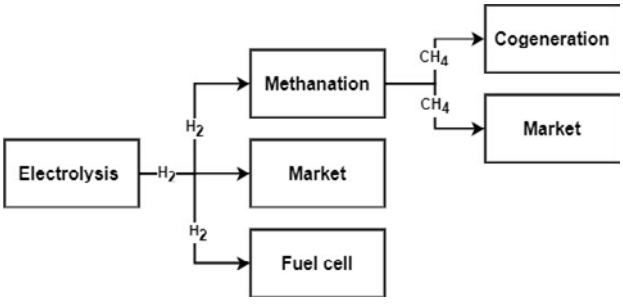
Abstract – Up to 60 % of Latvia's energy resources are used as fuel for district heating systems. Heating sector is an important emitter of greenhouse gases – especially carbon dioxide. Therefore, reduction of carbon emissions of district heating systems are crucial in Latvia's decarbonization efforts. One of the solutions is integration of energy hub in the district heating network. There are many types of energy hubs, and the most suitable solution must be found in each case. A goal of this study is to find the best solution for Latvia's district heating systems to achieve decarbonization and use of green (renewable) hydrogen. This coincides with European Union's plans to increase the use of green hydrogen not only in industrial and residential application, but in heat production as well. To facilitate the plans of the European Union and Latvia's decarbonization needs, a mathematical model made in Microsoft Excel is used as a method to explore the techno-economic aspects of the energy hub and its integration in the district heating system. Several alternatives are considered, and green hydrogen is used in all of those. Results show the economically most feasible alternative. Calculations are made on an annual term basis, considering such factors as electricity and district heating price, required capacity of electrolysis apparatus for hydrogen production, etc. From the model some results are apparent – the price of electricity has a sizable impact on the economic feasibility of the project, and the best use for green hydrogen economics-wise may differ throughout the year as the price of electricity, hydrogen, district heating and methane gas change.

Keywords – Centralized heating; decarbonization; green hydrogen; renewable energy; renewable hydrogen; sustainable energy system



Microsoft Excel techno-economic model scheme.

https://doi.org/10.7250/CONECT.2024.018

INTEGRATING LOW TEMPERATURE WASTE HEAT IN DISTRICT HEATING SYSTEMS. LEGAL FRAMEWORK AND PRICING

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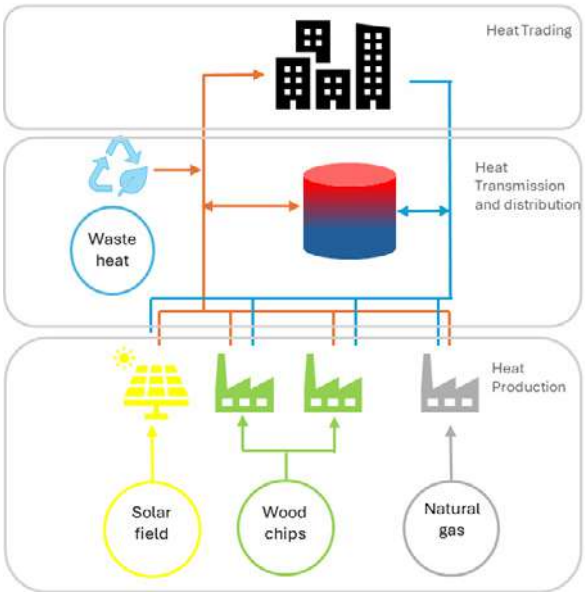
Abstract – Decarbonisation of the heating sector is a key challenge for the European Union to achieve its ambitious goals of becoming the first climate-neutral continent in 2050. Decarbonising the heating sector is about reducing fossil fuel consumption and finding new scenarios based on renewables and restructuring the operation of district heating system. Recovering and integration waste heat into the district heating system has an enormous potential to meet the heating needs of households through non-combustion technologies while reducing carbon emissions. The heat from urban sources of waste heat is advantageous because the heat sources are close to district heating networks and close to areas with high heat demand. However, there is still no legal or regulatory framework for the use of waste heat and no incentives for its use in district heating in the Member States of EU. This paper has two main objectives: firstly, to consider different pricing and cost determination scenarios when the waste heat is integrated into the district heating system. The heat tariff calculation model is based on the approved Latvian heat tariff calculation methodology. Secondly – to consider a mathematical model for the pricing of waste heat. The waste heat integration strategies are tested on the case study of district heating system in Salaspils, Latvia. Simplified model of a waste heat recovery system that recovers heat energy from a wastewater treatment plant through heat pump integration is developed.

Keywords – District heating; heat tariff; low temperature waste heat; modelling; waste heat



Heat Tariff Pricing model.

https://doi.org/10.7250/CONECT.2024.019

ENHANCING THE EVALUATION OF DISTRICT HEATING SYSTEM RESILIENCE: A LITERATURE REVIEW

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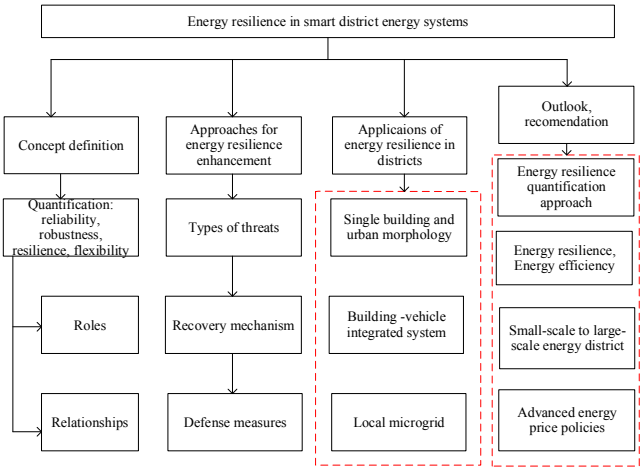
Abstract – Ensuring an uninterrupted supply of energy, electricity, and heat is becoming an increasingly pressing necessity. Energy provides both social and economic growth, therefore, the energy systems should be resilient to different external conditions. Resilience is the ability of a system to recover from adversity and in connection with the critical infrastructure - the ability to prepare for and adapt to changing conditions and withstand and recover rapidly from disruptions. Resilience includes the ability to withstand and recover from deliberate attacks, accidents, or naturally occurring threats or incidents. Several factors influence the resilience of the energy supply system: energy security, reliability, robustness, flexibility, and resilience. If energy resilience has not been well considered or even ignored in the planning, design, and operation stages in district energy communities can lead to system fragility and vulnerability. Therefore, the research assesses the different methods for resilience assessment in energy systems by focusing on district heating. During climate change mitigation and adaptation energy supply system resilience is unclear. Based on current studies, the energy resilience factor for most is considered in the context of the electricity transmission system, and the heat transmission resilience study is limited. During the research of the literature, it has been concluded that there is no consistent quantitative and quality approach to resilience because there is no consistent treatment of the concept of resilience. The available literature sources about energy resilience are limited in their scope and usability and hence are not amenable for use outside the scope where they have been developed. The metric and formula used for calculating resilience, if any, and the input data required for such calculations are also dependent on the research scope. There is a need for a fundamental generic quantitative and quality approach for resilience that would be usable and useful across various scopes or sectors in a consistent manner, which can be used for the development of resilient systems and effective resilience strategies for district heating systems.

Keywords – District heating systems; resilience assessment; smart energy systems



An overview of energy resilience in smart district energy systems.

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ADAPTIVE BUILDING ENVELOPE STRUCTURES

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Abstract – Buildings in the European Union account for 40 % of energy consumption and 36 % of greenhouse gas emissions. These numbers highlight the urge to address building energy efficiency improvement and the reduction of related emissions. There are promising trends to reduce building energy consumption and provide innovations in the sector of building thermal envelope – active and adaptive building envelopes. These approaches perceive thermal envelope as a media that transforms and transmits the energy available outside to the user inside of the building or changes its properties in response to the changes in surrounding conditions (temperature fluctuations, solar radiation level, etc). This study investigates the application of biomimicry principles in the development of an innovative adaptive facade with energy storage capabilities. Important step in applying the biomimicry approach is to explore suitable nature strategies, that can help to solve the technological challenge. Thus, inspired by the natural mechanisms employed by animals that utilize fat tissue for energy storage, research focuses on cataloguing such animals to gather significant data on the characteristics of both the animals and fat tissue. Through systematic observation and analysis, study offers a catalogue highlighting the unique strategies employed by various species to store and utilize fat reserves, offering valuable insights for biomimetic design that can be used for further transfer to the technical design.

Keywords – Adaptive building envelope; biomimicry; building energy efficiency, energy storage

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AIR FLOW ANALYSIS FOR TRIPLY PERIODIC MINIMAL SURFACE HEAT EXCHANGERS

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Abstract – Due to the increasing popularity of additive manufacturing technologies, more varied and complex shapes of heat exchangers can be produced, that can be optimized to be more compact and efficient. In this paper a triply minimal periodic surface – gyroid structure – is designed to study the applicability of such structures in air-to-air heat exchangers used in residential ventilation recuperation systems. Gyroid surface structures are useful to decrease overall heat exchanger size, pressure and increase heat transfer. Several geometry variations with different flow rate values were analysed to compare the efficiency of heat exchanger designs, as well as basic counterflow plate heat exchanger arrangement was analysed, to compare the gyroid designs to conventional methods. To calculate the pressure difference, temperature and heat transfer in each variation, SolidWorks Flow Simulation was used. The results showed that by using gyroid structures, heat exchanger energy transfer can be optimised for required back pressure and heat transfer, while reducing the overall dimensions, compared to conventional heat exchangers. By incorporating low cost, printed thermal recuperators, thermal efficiency of residential buildings can be improved. Suitable materials, manufacturing methods and application limitations are discussed.

Keywords – Additive manufacturing; CFD; gyroid; heat transfer; thermal recuperator

ACKNOWLEDGEMENT

This work has been supported by the European Recovery and Resilience Facility within the project "Research and application of flow dynamics and heat-exchange processes in the development of micro-heat recuperator systems" No. 5.1.1.2.i.0/1/22/A/CFLA/006

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SAFE INSULATION FROM THE INSIDE AS A SOLUTION TO THE ENERGY AND CLIMATE CRISIS

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Abstract – Along with rapid climate changes, issues related to the energy efficiency and efficient use of energy are becoming more and more relevant in the EU. One of the energy-consuming sectors is buildings, which are responsible for about 40 % of the EU final energy consumption and 36 % of CO_2 emissions. In addition to this, the current energy crisis has acutely raised the issue of energy poverty. Therefore, one of the ways to fight with energy poverty and high energy consumption in buildings is insulation from the inside. However, warming from the inside is risky due to hygrothermal processes and mold risks. This study assesses the hygrothermal performance of masonry walls with 9 interior insulation systems exposed to different external conditions in the climate chambers. Masonry walls were tested in a steady cycle, a dynamic cycle, a dynamic cycle with rain and a steady cycle as drying. Also, an identical simulation of the hygrothermal process was carried out in the DELPHIN software to compare results of both testing methods. Both vapor-open and vapor-tight systems were chosen as insulation systems. The results show that the hygrothermal behavior of vapor-open and vapor-tight insulation systems is different under different test cycles regarding different vapor diffusion resistance of materials. Mathematical simulations results are different from the climate chamber simulations because of the change in material humidity that is changing during climate chambers simulations. From this it can be concluded that mathematical simulations do not give a complete vision of hydrothermal processes because they are dynamic, but in modelling the properties of materials are defined. The study provides valuable data on hygrothermal processes in different wall insulation systems from the inside.

Keywords – DELPHIN; energy consumption; energy efficiency; hygrothermal; relative humidity

ACKNOWLEDGEMENT

This study is part of the author's Master's Thesis "Safe insulation from the inside as a solution to energy and climate crisis", which is being developed at the Riga Technical University, in the study program "Environmental Engineering".

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GEOSPATIAL ANALYSIS OF ENERGY POVERTY AND ACCESSIBILITY TO DISTRICT HEATING SYSTEMS

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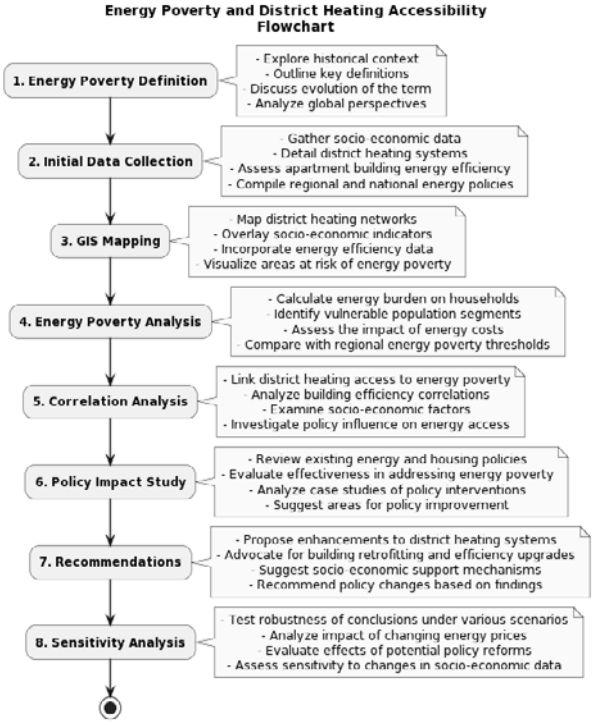
Abstract – This research paper undertakes a comprehensive geospatial analysis to investigate the relationship between energy poverty and district heating accessibility in Estonia. Utilizing ArcGIS Pro and statistical software, the study maps district heating systems, evaluates the energy efficiency of apartment buildings, and examines socioeconomic factors influencing energy poverty. By integrating GIS data with socioeconomic and building energy performance indicators, the research identifies areas where district heating is either absent or inefficient and correlates these findings with instances of energy poverty. Preliminary data may indicate a significant correlation between the lack of accessible district heating and increased energy expenses among lower-income households. The study also evaluates the impact of building energy efficiency on heating needs, revealing that older, less efficient buildings contribute disproportionately to energy poverty. Recommendations include policy interventions to expand and optimize district heating networks, alongside building renovation programs to enhance energy efficiency. This research contributes to the broader understanding of sustainable urban heating solutions and their role in mitigating energy poverty.

Keywords – Building renovation; energy policy; Estonia; fuel poverty; Geographical Information System (GIS); socioeconomic impact; sustainable urban development



Methodology description.

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THE CREATION OF A NEW MODEL OF A GAS-TURBINE ELECTRIC POWER-GENERATING DEVICE

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Abstract – A hypothesis on the possibility of creating an electric power gas turbine device running on fuel gas is proposed, and the results of preliminary research experiments are given to evaluate the validity of this hypothesis. The assessment criteria for mixing fuel gas and air and the quality of combustion have been identified. In particular, it has been found that the burning of fuel gas with a blue flame in a combustion chamber of a particular, proposed design, is an indication that the content of the fuel gas mixture is optimal, the mixing process is perfect, and the exhaust gas is completely expelled from the combustion chamber. It has also been revealed that the criteria for quantitative assessment of the quality of the fuel gas combustion process is the force of the exhaust gas blown out of the combustion chamber acting on the blade of the gas turbine. It is shown that the optimal content of the propane-air mixture at atmospheric pressure is 92 % air + 8 % propane, and the force of the exhaust gas flow acting on the air turbine blade was 5 dekanewtons. The calculation shows that the action of total force of two chambers on the gas turbine blade can overcome the reaction force of the generator armature with a capacity of at least 1000 W. As it is seen from the given approximate simple calculations, a large amount of electricity can be generated by the proposed gas turbine devices if they are equipped with an electric generator of appropriate capacity and the appropriate number of combustion chambers. To determine the parameters of the proposed design of the combustion chamber of the gas turbine device, such as diameter, height, and volume, materials are provided based on the experiment, and an image is obtained that establishes a relationship between the force of the combustion chamber acting on the gas turbine blade and the mentioned parameters.

Keywords – Electric generator; combustion chamber; gas-turbine unit; gaseous fuel; heat-and-power; heat energy

ACKNOWLEDGEMENT

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VALIDATING ANSYS HEAT TRANSFER MODELS USING EXPERIMENTAL DATA ANALYSIS OF TWO PHASE CHANGE MATERIALS WITH DIFFERING MELTING TEMPERATURES

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Abstract – Phase change materials are becoming more and more popular as viable options for improving the thermal performance and energy efficiency of a variety of applications, especially in innovative building envelope designs. In this paper, experimental data from two different phase change materials with differing melting temperatures (21 °C and 28 °C) are used to validate numerical system heat transfer models. The experimental setup included a heat flux apparatus, which was utilized to ascertain average temperature and heat flow changes over time during both heating and cooling phases for both phase change materials. The data obtained from the experiments were utilized to generate ANSYS Fluent simulation models replicating the experimental setup. The parameters and boundary conditions for the models can be assigned in several ways within ANSYS Fluent software. Consequently, two simulation models were created: one integrated the thermal and physical properties of the experimental setup's system components, while the other utilized the measured heat-flux values over time from the experiments as an input source for calculating average temperatures within the phase change material. The average temperature data from both simulation and experimental results were compared to validate both ANSYS models. By aligning the simulated results with the experimental data, the accuracy and reliability of the numerical models have been established in predicting the thermal behaviour of the two phase change materials. The two numerical system heat transfer models developed in this study serve as valuable tools for conducting further analysis and optimization of systems based on phase change materials. This research highlights the significance of phase change materials in enhancing the thermal performance of building envelopes, particularly in solar energy applications.

Keywords – ANSYS Fluent; heat flux apparatus; numerical models; phase change materials; thermal performance

02

ENERGY AND ENVIRONMENTAL MODELLING

https://doi.org/10.7250/CONECT.2024.026

LIFE CYCLE ASSESSMENT FRAMEWORK FOR DIAGNOSTIC IMAGING

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Abstract – The increasing focus on environmental sustainability is becoming essential in the diagnostic imaging sector, which is accredited for about 10 % of the healthcare industry's carbon footprint. A multitude of research initiatives investigated the environmental impacts of diagnostic imaging, encompassing factors like electricity consumption, carbon emissions, and waste generation from these procedures. Life Cycle Assessment (LCA) stands as a prominent method for structural assessment of environmental impacts, offering a detailed framework for examining the environmental consequences of specific processes. The aim of this study includes analyzing existing LCA approaches in literature to identify their limitations and to suggest an elaborate framework for LCA application in diagnostic imaging. Out of 17 original articles on environmental sustainability in radiology published since 2014, but only a part, 29.4 % (5/17), described an LCA approach. The different characteristics of these studies provide valuable insights, enabling the proposal of a more comprehensive LCA research methodology. The reviewed articles did not present a uniform research outcome. According to the GreenHouse Gas (GHG) Protocol Corporate Standard, the optimal outcome for assessing environmental impact is the calculation of greenhouse gas emissions. For a thorough methodological approach in LCA, it is essential to cover all direct and indirect emissions associated with diagnostic imaging. All studies (100 %, 5/5) considered the electricity consumption of imaging equipment. Usage of consumables was included in 80 % (4/5) of studies. Only 40 % (2/5) of articles considered auxiliary equipment, such as computers and contrast-medium injectors, as well as heating, ventilation and air conditioning (HVAC) systems. Equipment manufacture, staff travel, and waste generation, though crucial to overall greenhouse gas emissions, were each covered in only 20 % (1/5) of the studies. The articles also varied in their LCA versions, with two employing the detailed Cradle-to-Grave approach, while others used partial Cradle-to-Gate and Input-Output LCA methods. The insights from this analysis could lead to a valuable framework for a new LCA methodological approach in diagnostic imaging. This novel approach is designed to overcome the limitations observed in existing research, offering a more comprehensive analysis. By enhancing the LCA framework, it will be possible to identify the phases in diagnostic imaging that have the most substantial environmental impact, allowing for the development of more targeted strategies to reduce GHG emissions associated with diagnostic procedures.

Keywords – Electricity consumption; environmental sustainability; GreenHouse Gas (GHG) emissions; healthcare sector; radiology; research methodology

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SURGICAL PROCEDURES FOR A GREENER FUTURE: AN APPROACH TO ASSESS THE ENVIRONMENTAL IMPACT

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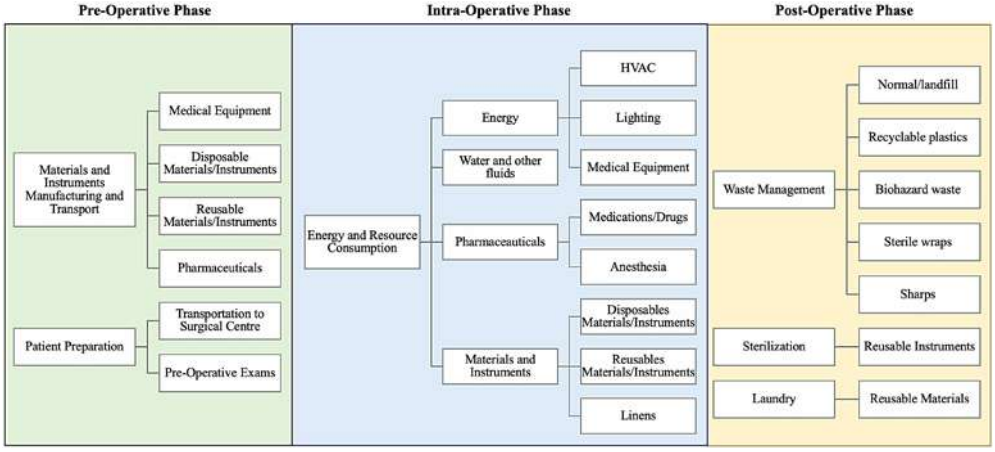
Abstract – The healthcare sector is responsible for around 4.4 % of worldwide greenhouse gas emissions, according to estimates. These emissions comprise both direct and indirect sources, with direct emissions encompassing aspects like patient transport, fuel consumption, and anaesthetic gases. Indirect emissions are associated with energy usage, including electricity purchases, as well as the products employed in healthcare, such as drugs and medical supplies. Operating rooms (OR) are responsible for the greatest rate of resource consumption and overall hospital waste, varying from 20 % to 33 %. Hence, it is essential to comprehend the environmental impact of surgical procedures to obtain insight into the total emissions associated with the healthcare sector. Moreover, the lack of uniformity in data collection and the discrepancy of the data used by researchers makes it challenging, if not ineffective, to conduct a rigorous scientific comparison among the currently available studies on the environmental impacts of surgical procedures. This study aims to provide a practical and standardised framework that can be utilised to evaluate, simply and consistently, the environmental impacts of surgical procedures. The adoption of a uniform methodology guarantees the inclusion of important variables and factors, preventing any oversights in the evaluation of the entire process. This allows for emphasis on the most sustainable techniques and permits the identification of controllable factors that can be modified within a short timeframe and are under the direct control of healthcare professionals. These factors include the selection of disposable or reusable instruments, the use of different anaesthetic gases, and the installation of different equipment.

Keywords – Framework; Greenhouse gas (GHG); Life Cycle Assessment; Operating room (OR); surgery; waste management



Data collection scheme to assess the environmental impact of the surgical procedure.

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CHALLENGES IN STANDARDIZING GLOBAL EMISSION FACTORS FOR PEATLANDS

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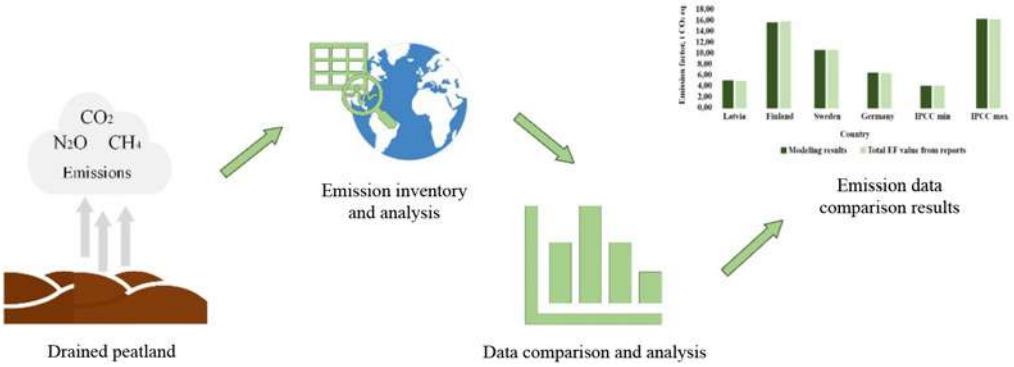
Abstract – Peatlands have a crucial role in the global carbon cycle, acting as significant carbon sinks, but become a significant source of greenhouse gas (GHG) emissions when peat extraction is taking place. This article presents a comprehensive overview of peatland ecosystems, emphasizing their classification across various climatic zones and the complex set of different characteristics that determine contribution to GHG emissions. Currently, inconsistency exists in definition of emission factors used between countries leading to varied approaches in estimating peatland emissions and posing significant challenges in the comparison and aggregation of global data on peat extraction related GHG. The aim of the study is to analyse the disparities in emission factors and calculation methodologies employed by different countries. Data from national GHG emission reports are submitted under the UNFCCC and the Kyoto Protocol. Emissions report data calculations and emission factors can be based either on nationally determined data or on data specified in the IPCC guidelines. Consequently, emission factor data for four countries – Latvia, Finland, Sweden and Germany – are collected and processed, which are compared to IPCC guideline data. The data were compared in two ways: by equating units of measurement and by modelling. The results have shown the pronounced difference between the emission factors of each country. However, all these factors are lower than the maximum values specified in the IPCC guidelines. It was also determined that comparing the total emission factors with the modelled results, no significant difference is observed between these results. The study concludes that emission factors are predetermined differently for each country, and it is not possible to specify the differences among assumptions for parameters included in the determination of the emission factors. The results suggest that there is a need for development of more transparent accounting of emissions with regard to the diverse environmental and anthropogenic factors influencing peatland ecosystems. Such factors as composition, depth of peat, water table levels, and local land-use practices, further compound this variability in emission accounting. Addressing these challenges is crucial for enhancing the accuracy and reliability of GHG emission reporting under international frameworks, such as the United Nations Framework Convention on Climate Change and the Kyoto Protocol.

Keywords – Carbon sink; climate change, emission inventories; peatland emissions; peat and peatland types; tier



Emissions accounting and analysis cycle for peat bogs.

ACKNOWLEDGEMENT

The work has been developed as part of the Fundamental and Applied Research Project "Sustainable Strategies for the Restoration of Peat Mining Sites (Peat4Res)", project no. lzp-2022/1-0405, within the framework financed by the Latvian Science Council.

FLPP
FUNDAMENTĀLIE UN LIETIŠĶIE PĒTĪJUMU PROJEKTI

Peat4Res

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VERTICAL HALOPONICS: SUSTAINABLE AND RESILIENT PRODUCTIONS USING BRACKISH WATER

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Abstract – While the rapidly growing global population will require a significant increase in food production in the next years, the current climate, sanitary and geopolitical crises highlight the weaknesses of the actual food production systems, excessively dependent on external inputs and involving extremely complex nested scales and non-linear processes. Thus, appears the need of accelerating the transition toward agricultural solutions and food systems based on the principles of the 'Green Deal', encompassing ecological resilience, environmental sustainability, local production, and universal access to healthy foods. Aquaponics (AP) can provide short and eco-friendly food supply chains with increased resource-use efficiency, high environmental sustainability, and food resilience. The sustainability of AP systems could be further increased by exploiting water resources that are not suitable for other purposes (brackish and salt water – haloponics), applying the vertical farming technology for both aquatic and vegetable species, reducing the use of fish meal in aquafeeds, valorising the system residues (sludge) for agronomic purposes. The VERTICHALPONICS project aims to develop an innovative food production system by implementing an interdisciplinary approach. Since aquaponics combines recirculation aquaculture and hydroponics, within a close loop, it is considered environment friendly. However, given the different technical approaches, it is necessary to evaluate the differences in impacts and specially to assess whether the vertical system is really resource-efficient and economically viable for farmers, in comparison to the business-as-usual. The environmental and economic sustainability of the system is measured by the mean of a combined LCA and the LCC analysis (EN ISO 14040-44 and ISO 156865:2017 standards). The system expansion will be used to evaluate the beneficial effect of reducing the overall environmental burden from by-product recovery and utilization of side wastes, specifically the sludge produced. The methods applied are Recipe and IPCC 2013 Global Warming Potential 100a. Environmental impact indicators will be provided using both mid-point and end-point categories thanks to the Recipe Method, while the IPCC 2013 Global Warming Potential 100a will be applied to calculate the direct global warming potential of the system. Moreover, the inclusion of the agronomic valorisation of the sludge will be analysed to understand the potential in terms of avoided impacts.

Keywords – Haloponics system; Life Cycle Assessment (LCA); Life Cycle Costing (LCC); Vertical Farming

ACKNOWLEDGEMENT

This work has been supported by the European Union – Next Generation EU, within the project "Vertical haloponics: exploiting brackish water resources for sustainable, resilient and high valuable aquaponics productions" PRIN 2022 PNR P202277Y78.

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PROPORTIONING OF OIL SHALE ASH FOR SUSTAINABLE 3D PRINTABLE MORTARS

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Abstract – To achieve optimal strength and printability, mortars used in 3D printing typically contain high proportions of cement and other fine-grained powders. Consequently, the majority of mixtures used in 3D printing have high carbon footprint. Hence, there arises a critical need to study alternative supplementary cementitious materials aimed at reducing the environmental impact of mortars used in 3D printing. The use of oil shale ash as a partial substitute for cement not only addresses this issue but also presents an opportunity to repurpose waste from power plants in the Baltic states, where oil shale is intensively utilized. In this study, the influence on mechanical properties and durability of cement-based mortars was evaluated by substituting cement with oil shale ash in varying quantities. Specifically, 0 % to 40 % of cement mass was replaced with oil shale ash. Life cycle assessment (LCA) was performed for each mixture. By analyzing the material properties alongside the environmental impact for each mixture, the optimal percentage of substitute was determined. For the determination of the mechanical properties of each mixture, compressive and flexural strength tests were conducted on 3D printed samples in various directions, as well as on cast samples. To assess the durability of each mixture, freeze-thaw tests were performed on both 3D printed and cast samples. From the obtained results, we developed an algorithm that chooses the optimal mixture proportioning. Depending on material performance requirements set in the beginning, this algorithm gives the exact proportions of oil-shale ash and cement for the mixture by taking into account both desired material properties and carbon dioxide emissions. As a result, an environmentally friendly cement-based mixture is obtained without losing the desired properties. By using this algorithm, it is possible to create a mortar with properties comparable to concrete with strength class C30/37 while reducing carbon emissions by 15 % to 30 %.

Keywords – Additive manufacturing; cement-based composite; Life Cycle Assessment; oil shale ash; sustainability; waste materials

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This research is funded by M-ERA.NET network under the research project “Transforming Waste into High-Performance 3D Printable Cementitious Composite”.

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ASSESSING ENVIRONMENTAL IMPACT: ORGANOSOLV EXTRACTION OF CELLULOSE PULP FROM WOOD WASTE

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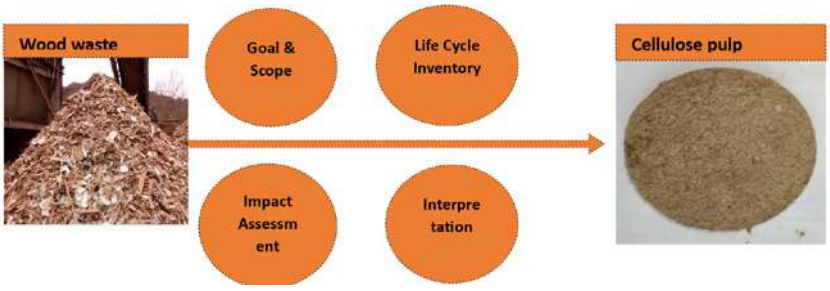
Abstract – In the upcoming years, the paper industry is expected to rely on containerboard for packaging, with approximately 80 % of it being made from recycled fibers by 2020. Creating a new supply chain for fibers could help mitigate possible shortages. In this context, wood waste emerges as a valuable resource with the potential to serve as a plentiful and cost-effective reservoir for generating new materials such as cellulose fibers. This study presents an assessment of the environmental impact associated with the organosolv extraction of cellulose pulp from wood waste based on a previous in lab study conducted by the authors. The increasing demand for sustainable materials has prompted exploration into alternative methods for cellulose pulp production, with a focus on minimizing environmental footprint. Organosolv extraction, a promising technique, involves the use of organic solvents and acid catalysts to break down lignocellulosic biomass, resulting in high-quality cellulose pulp production. To evaluate the environmental implications of this process, a comprehensive life cycle assessment (LCA) approach was adopted. The LCA framework considers all stages of the organosolv extraction process, from wood waste collection to cellulose pulp manufacture, using a gate-to-gate approach. The functional unit for assessment is set as one ton of cellulose pulp. The dataset utilized for the LCA comprises primary data obtained from laboratory experiments, complemented by secondary data sourced from literature and the Ecoinvent life cycle inventory database. Furthermore, sensitivity analysis was conducted to assess the influence of key parameters on the environmental performance of the organosolv extraction process, with a focus on variations in energy consumption to identify potential areas for optimization and improvement. In summary, this study emphasizes the environmental aspects of utilizing organosolv extraction for cellulose pulp production from wood waste. Further research is warranted to explore energy consumption during the organosolv process for obtaining more precise data and optimizing the process. This could be achieved through pilot-scale experiments or utilizing process simulation software.

Keywords – Delignification, LCA (life cycle assessment); pulping; recycling



ACKNOWLEDGEMENT

The authors would like to acknowledge Fondazione Perugia for supporting the present research under the project entitled “CELLWOOD – Valorizzazione dei rifiuti in legno per la produzione sostenibile di materiali ad elevato valore aggiunto” (CELLWOOD – Waste wood valorization for sustainbale production of high add value materials). The authors would also like to acknowledge Gesenu Spa for their partnership in this project and for sharing their data.

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CLIMATE CONSCIOUS COMMUNITIES: NAVIGATING TRANSFORMATION THROUGH SIMULATION GAMES AND CREATIVE ENGAGEMENT

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Abstract – In the context of the European Green Deal and rapid climate change, significant changes in people's habits are necessary, transforming their behavior from resource consumers' to climate-responsible individuals'. Addressing challenges, such as biodiversity loss, engagement in the development of a circular economy, responsible energy consumption, and resource sharing, requires changes in individuals' attitudes and behaviors. However, individuals often lack understanding of the climate system, its link to the quality of life, and the impact of actions based on individual interests on societal transformation processes as a whole. Governments and international organizations implement various complex measures, but the dynamics of climate change by far exceeds society's ability to adapt. To address these challenges, the authors of this paper propose using simulation games as an effective learning method. These games provide individuals with an opportunity to gain a new, community-oriented decision-making experience without creating negative effects on real systems due to inappropriate decisions. Simulation games help to better understand cause-and-effect relationships, factors influencing individual attitudes and behaviors, evaluate the consequences of decisions made, and motivate practical involvement in mitigating climate change. In order to improve the attractiveness of using the simulation game, cultural and creative industry competences are integrated, which contribute to the improvement of content, visualization and interaction. The paper examines an organizational model for simulation games that assists municipalities and other stakeholders in developing customized simulation games to promote the development of climate-responsible communities. Considering the necessity to engage diverse social groups with varying levels of digital skills, an analog format has been chosen for the simulation game, without excluding the possibility of transforming it into a digital one. The proposed model includes setting objectives, integrating elements into a holistic simulation game, and piloting the framework using examples from municipal practice. To optimize the applicability of simulation games, they need to be adapted to the geographic area and community due to individual processes and structures.

Keywords – Attitudes; behavior learning method; climate-responsible individuals; culture and creative industries

ACKNOWLEDGEMENT

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INCORPORATING LIFE CYCLE ASSESSMENT IN THE GREEN METRIC RANKING: A CONCEPTUAL APPROACH

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Abstract – Integrating sustainability principles into their daily operations is an overarching goal of universities and higher education institutions (HEIs), as knowledge multipliers, have to perform (Filimonau *et al.*, 2021). Various studies have demonstrated that the operational activities of universities cause GWP emissions and, in general, negative environmental impacts, due mainly to student and staff mobility, oncampus energy and water consumption, and waste production (Jürgens *et al.*, 2023). Findler *et al.* (2019) outlined numerous analytical methods, ranging from input-output analysis to full Life Cycle Assessment (LCA), for evaluating the carbon footprints of universities and colleges. Concurrently, a variety of tools have been devised to measure sustainability based on environmental metrics, such as the Green Metric (GM) ranking developed by Universitas Indonesia (UI). The GM, which is first in which tops university sustainability rankings (Marrone *et al.*, 2018), rates HEIs by utilizing 51 criteria across 6 rating areas. Researchers analyzed the UI Green Metric World Ranking system to examine the requirements for a fair sustainability ranking of worldwide HEIs, although the latter were only examined in general without inspecting each item separately (Boiocchi *et al.*, 2023). In order to lessen the environmental impacts of HEIs, recognized and robust methods must be used to identify appropriate and effective measures. LCA is a standardized (ISO 14040 and 14044) tool for quantifying and reducing environmental impacts throughout the entire life cycle of a product, service, or organization. This study is focused on understanding how LCA can be integrated into GM, and more specifically, how it can assist in achieving a consistent and structured review of specific indexes such as EC4, EC7, EC8, WR2, and TR1. The analysis was conducted by comparing the items one by one. Such a method was implemented as a result of the authors' specialized background, the scientific literature of interest, and the adoption of a critical thinking approach. The study results emphasize the necessity of incorporating LCA into the environmental sustainability strategies of HEIs. This integration is crucial for developing a robust approach adaptable to various local contexts, enhancing the precision in assessing and improving HEIs' sustainability practices. Such a strategy will align HEIs' operational activities more effectively with sustainable development goals. The application of the conceptual approach to a case study is recommended.

Keywords – GreenMetric; Life Cycle Assessment; sustainability; university campus

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WILL CHANGING HABITS ENSURE SUSTAINABLE MOBILITY: SYSTEM DYNAMICS MODELLING EXAMPLES FROM MUNICIPALITIES IN FOUR COUNTRIES

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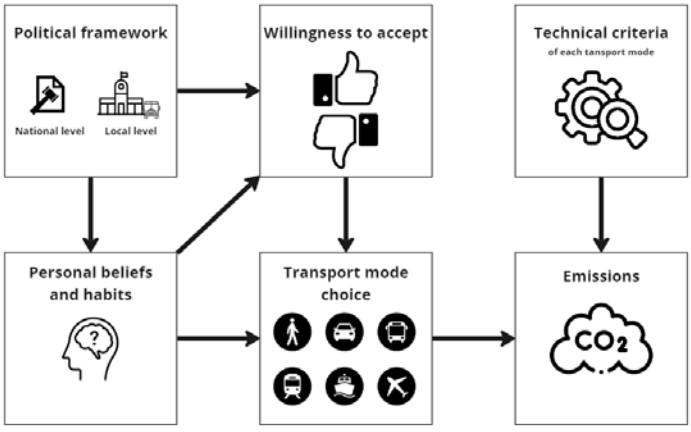
Abstract – The transportation industry stands out as a significant contributor to world emissions, which presents a significant obstacle to the process of decarbonization. This study recommends a comprehensive plan that addresses emissions not just at a national level but also at a local and individual level, with an emphasis on using a multi-dimensional approach. Our study aims to support municipalities in assessing and mitigating transportation-related emissions by using a system-dynamic approach and introducing a state-of-the-art instrument. In contrast to conventional assessments, which are primarily concerned with technical criteria, our approach takes into account the everyday routines of inhabitants as well as their willingness to accept sustainable policies. Dynamic modelling enhances our understanding of the intricate correlation between technical metrics and socio-behavioural dynamics. This allows us to provide municipalities with a strong basis for creating effective initiatives to reduce emissions. This research adds to the subject of sustainable urban planning by promoting the increased public acceptance of sustainable mobility schemes and encouraging active public involvement. This analysis allows municipalities to build policies that not only target technical emissions but also integrate smoothly into the social framework of the local community. This is made possible because this study emphasizes the relevance of holistic and community-centred approaches. For municipalities that are attempting to navigate the complexities of emissions reduction in the transportation sector, it gives significant insights that highlight the requirement of policies that are both inclusive and adaptive to promote a sustainable urban future.

Keywords – CO_2 emissions; local policies; SD modelling; socio-behavioural dynamics; transport sector



Research methodology.

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SUSTAINABLE FISH FEED: A COMPREHENSIVE LIFE CYCLE ANALYSIS

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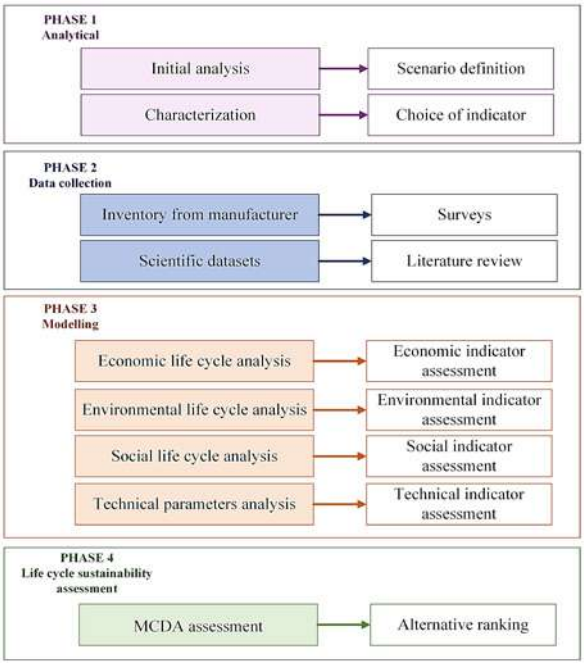
Abstract – The concept of sustainability is used as an interpretation in terms of three dimensions – environmental, economic, and social dimensional balance. Several methodologies and tools have been developed to enable sustainability assessment in different sectors and different scales. To assess sustainability, it is necessary to clearly define the system and its elements and to select the appropriate indicators. Each method has advantages and disadvantages, but combining several methods can help overcome a weakness. The aquaculture sector continues to grow all over the world, and therefore, to reduce the impact of the sector, it is necessary to evaluate reasonable alternatives. The aim of the study is to evaluate several fish feed compositions according to environmental parameters using life cycle analysis (LCA), for economic parameters using life cycle costs (LCC), for social parameters using social life cycle analysis (SLCA), as well as comparing technical parameters. The result is an evaluation of fish feed considering several dimensions, to benefit the fish from this feed, as well as to reduce the impact on the environment from the production of feed.

Keywords – Environmental assessment; economic assessment; social assessment; technical assessment



Phases of sustainable fish feed evaluation.

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REPLACING TRADITIONAL MATERIALS WITH MORE SUSTAINABLE ONES: THE USE OF PHRAGMITES AUSTRALIS (CAV.) TRIN. EX STEUD. AS BIO-BUILDING MATERIAL AND PELLET

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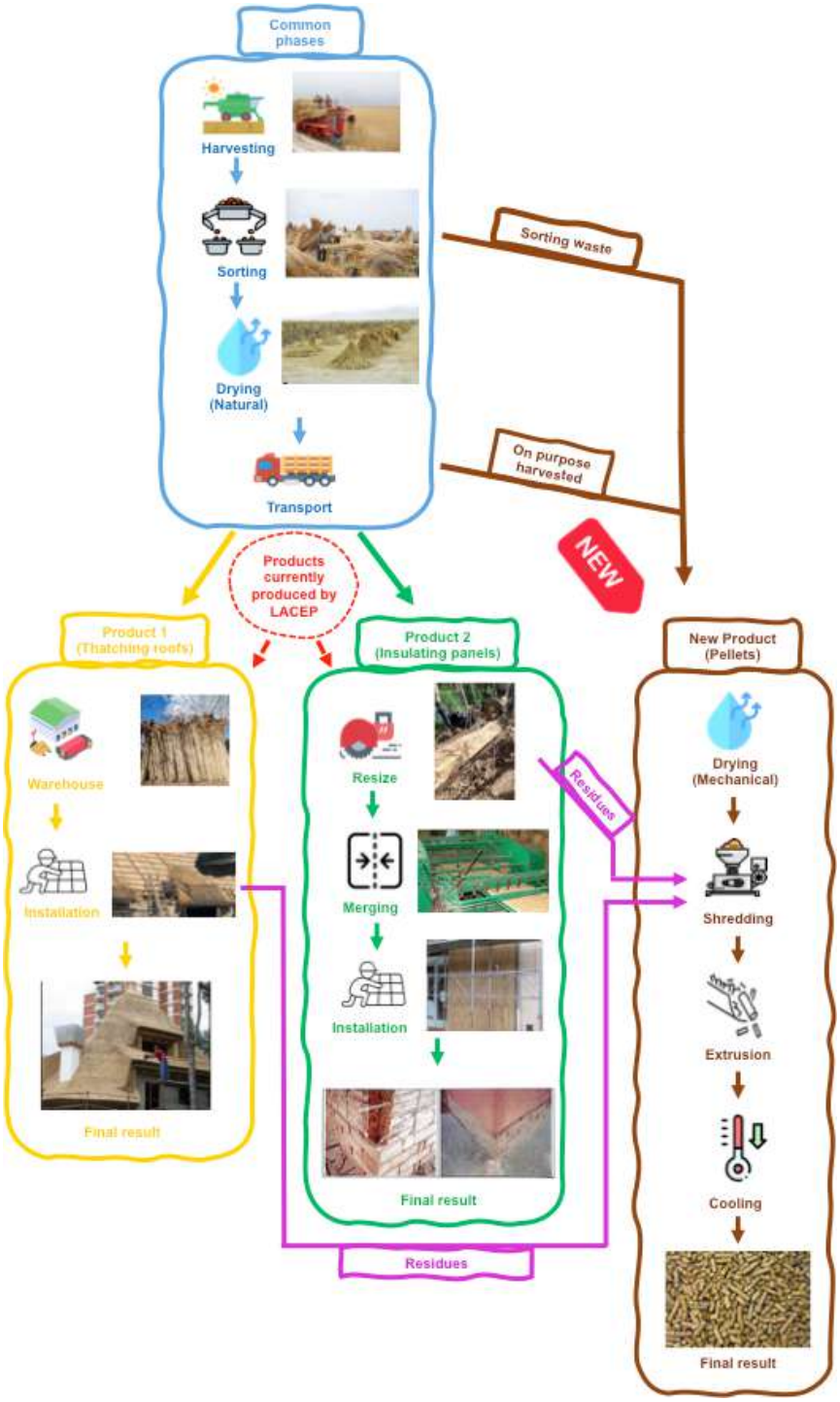
Abstract – Considering the hazardous future scenarios outlined for the environment by the scientific community and various institutions, embracing more sustainable production methodologies is imperative. This is especially vital within the construction and energy sectors, which stand as significant contributors to climate change and environmental impact. The topic presented herein aligns with this direction. Specifically, the aim of this study is to highlight the benefits of transforming conventional agriculture into a technologically advanced and environmentally sustainable practice. The proposed study is being carried out with the cooperation of a strategic partner operating in the bio-building sector from many decades. Two of the company's main products are the insulating panels and the thatching roofs made with the stems of *Phragmites australis* (Cav.) *Trin. ex Steud*. The goal of this study is twofold: on one hand to investigate the reduction of environmental impacts using reeds artifacts instead of traditional materials in the construction sector; on the other hand, to assume new utilization scenario for Phragmites australis, in order to reduce the processing waste, providing at the same time a wider range of products for consumers and a further income to the company. The hypothetical new scenario includes the production of pellets, combining the reeds harvested purposely with the processing waste or the unsuitable part of them for construction uses. All these scenarios will be investigated performing a Life Cycle Assessment, and this can be considered as a preparatory study for that kind of analysis. First of all, a comparison between the life cycle impacts of construction's products (insulating panels and thatched roofs) and the same products made with traditional materials (business as usual) will be performed. Secondly, difference in terms of impacts between reed pellets and traditional wood-pellets (business as usual) will be investigated, as well as the feasibility for the company to start this additional activity. Considering the rising attention to the environmental issues from the common people and the demand for green procurements from governments and communities, this study could provide a better company image, spendable on the market. Furthermore, the study will contribute to the achieving of 3 out 17 SDGs (Sustainable Development Goals) UN Agenda 2030, precisely No. 7 – Affordable and clean energy, Nr. 9 – Industry, innovation and infrastructure and No. 12 – Responsible consumption and production.

Keywords – Reed (Phragmites Australis (Cav.) Trin ex Steud.); bio-building; reeds panels; pellet; environmental impacts; alternative materials



Production Systems deriving from *Phragmites Australis*.

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LIFE CYCLE ANALYSIS OF A BATTERY ENERGY STORAGE SYSTEM

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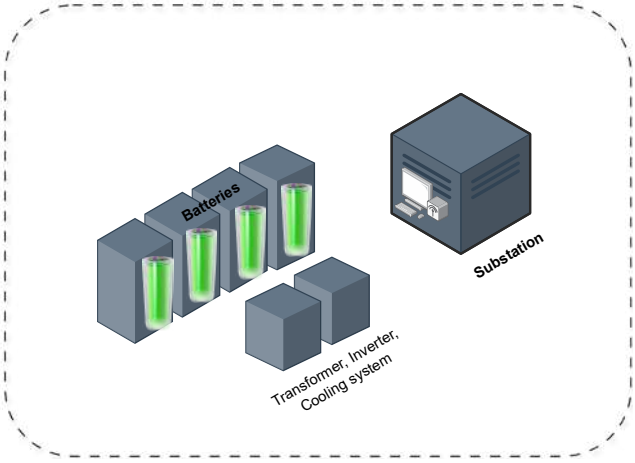
Abstract – For the Latvian Government and transmission system operator, energy security and independence has been an issue for a long period of time, even more when political situation changed, motivating to act faster in order to swich off from BRELL (grid connection with Russia and Belarus) system completely. Therefore, the three Baltic states have made an agreement on building more stable electricity transmission system within Baltic region and to connect with European transmission systems, building new stations with synchronous compensators and energy storage systems. In order to build a system that allows to include more energy from renewable resources and secure possible disbalances in system, the Latvian transmission system operator (TSO) is building a new battery energy storage system (BESS). This paper aims to look at the costs of this battery energy storage system from climate perspective to Latvia and its society in order to gain energy security and possibility to include more energy from renewable resources.

Keywords – BESS; Energy security; Energy and climate plans; LCA



Battery energy storage system overview.

https://doi.org/10.7250/CONECT.2024.038

CARBON FOOTPRINT OF A NEARLY ZERO ENERGY BUILDING IN ACCRA (GHANA): AN LCA-BASED MODEL

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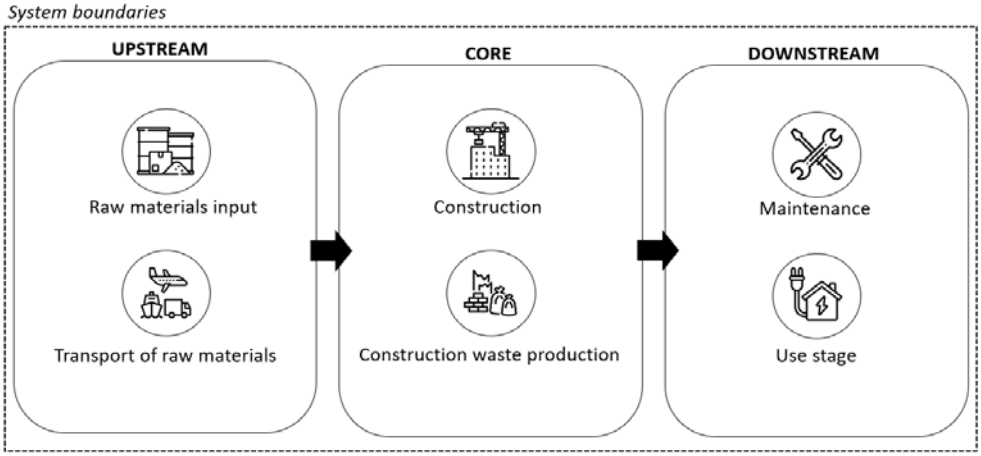
Abstract – This study presents a comprehensive Life Cycle Assessment (LCA) of a Nearly Zero Energy Building (NZEB) in Accra, Ghana, comparing its environmental impact with a conventional BusinessAsUsual (BAU) building over a 50-year lifespan. Adhering to ISO 14040 and ISO 14044 standards, the research evaluates the carbon footprint and operational efficiencies essential to sustainable building designs. Utilizing SimaPro 9.5 software and the IPCC 2021 GWP100 method, the total carbon footprint was quantified at 1727 tons of CO_2-equivalent for the NZEB, significantly lower than the BAU comparison. The analysis highlights the operational phase, including waste generation as the most substantial contributor to the NZEB's environmental impact, accounting for 725 tons of CO_2-equivalent emissions. Conversely, the strategic inclusion of solar panels and enhanced material selection for the NZEB markedly reduced energy demands, contributing to a net positive environmental outcome with an avoided carbon footprint of approximately –859.72 tons CO_2eq. This reduction underpins the NZEB's effectiveness in leveraging eco-friendly materials and renewable technologies, setting a benchmark for future sustainable construction practices. The study ultimately advocates for an integrated approach, harmonizing technological innovation with environmental stewardship, to mitigate the carbon footprint of the built environment, steering the construction industry towards sustainability.

Keywords – Carbon Footprint; environmental impact; Nearly Zero Energy Building; Life Cycle Assessment; renewable energy; sustainable construction



System boundaries of the NZEB study.

03

BIOTECHNOLOGIES, BIORESOURCES

https://doi.org/10.7250/CONECT.2024.039

CREATION OF SINGLE CELL PROTEIN-PRODUCING MUTANTS OF *PHAFFIA RHODOZYMA*

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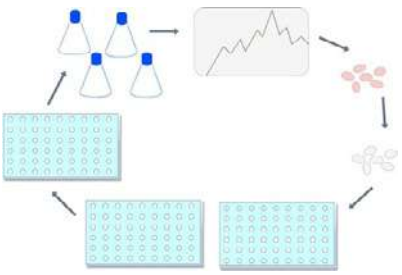
Abstract – Recently, there has been an increasing demand for sustainable protein sources for aquaculture that can be produced with a minimal environmental footprint, such as single-cell proteins, proteins from algae, insects, and by-products from the agricultural industry. Single-cell proteins that are derived from microorganisms show a sustainable alternative to traditional protein sources due to their high protein content and rapid growth. This research focuses on creating mutants of the yeast *Phaffia rhodozyma* to increase single-cell protein production. This yeast has significant industrial potential and biological features. The yeast *Phaffia rhodozyma* is already known for its unique ability to synthesize astaxanthin, so this case will focus on its ability to produce protein. In the present study, wild-type yeast strains DSM 5626 and previously obtained white mutants without the ability to synthesize astaxanthin were used for further random mutagenesis methods to introduce specific mutations into the genome aimed at improving their ability to biosynthesize protein. The amino acid inhibitor glufosinate-ammonium at a concentration of 50 mM was used as a specific pressure agent to select potential protein-producing mutants. Screening of potential mutants was carried out in 48-cell microplates by assessing cell growth using optical density measurements. The protein content of the biomass obtained from the experiments was analyzed in detail using BCA (Protein Assay Reagent) analysis, which confirmed their potential as a source of nutrients for aquaculture. This research showed that the yeast *Phaffia rhodozyma* can grow on a medium without an organic nitrogen source. The study also showed good potential in terms of protein content. During research, one of the white mutants showed the best results in comparison to other white mutants and the wild strain of yeast. The best result for protein in white mutant showed 26,8 % protein in biomass, while the new GA mutant had 20,8 % protein in biomass. The results obtained allow further research into the development of cost-effective and environmentally friendly alternatives for feed in aquaculture.

Keywords – Amino acid inhibitor; aquaculture; glufosinate-ammonium; herbicide; mutagenesis; sustainable protein sources



Process of creation single cell protein-producing mutants of Phaffia rhodozyma.

ACKNOWLEDGEMENT

The work has been developed by the Fundamental and Applied Research Project “Herbicides as tool for selection of edible protein-rich mutants”, project No. lzp-2022/1-0126, funded by the Latvian Council of Science.

04

RENEWABLE ENERGY TECHNOLOGIES

https://doi.org/10.7250/CONECT.2024.040

A HYBRID EXPERIMENTAL MODELLING APPROACH TO SOLAR PHOTOVOLTAIC CELL TEMPERATURE PREDICTION

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Abstract – Solar cell temperature is critical in the determination of solar energy generated by a solar photovoltaic power plant. High temperatures are associated with a reduction in the energy generated, and hence prediction of photovoltaic cell temperature is essential in temperature mitigation and solar energy forecasting especially in commercial power plants. The present study focused on the development of a machine learning based predictive model for solar photovoltaic cell temperature prediction in commercial solar photovoltaic power plants. A physical experimental set up was developed to measure solar cell temperature under different weather and other related parameters. Satellite data were also collated for those parameters difficult to measure experimentally and were used to complement experimental data used in this study. Satellite data used in the study were statistically transformed for each parameter used to mimic experimentally measured data. Statistical approaches were adopted to analyse the influence of both the dependent and independent variables on solar cell temperature. The analysis included multicollinearity and correlation analysis with the aid of heat maps meant to establish the relationships among the independent and dependent variables. Feature selection and dimensionality reduction was also performed to reduce the input variables and maintain relevant data in the modelling process. Parameters with a strong correlation to each other had some of them eliminated in the modelling process. A solar cell temperature predictive model based on selected weather parameters was developed using a machine learning approach (Random Forests), and parameters used were selected from the statistical analysis. The prediction accuracy of the developed model was analysed using the coefficient of determination (R^2) and the mean absolute percentage error (MAPE). The results indicated a higher model performance compared to generic models used in cell temperature prediction. The prediction MAPE for the developed model was 0.83 °C while an R^2 value of 0.93 was obtained, which was indicative of a good model. The developed model was also comparable to other contemporary models developed to predict solar photovoltaic cell temperature. Simulations were also done to determine the annual energy generated with the incorporation of the solar cell temperature prediction model. The results revealed a 3.4 % difference in the annual energy generated between a simulation which considered solar cell temperature and which ignored the solar cell temperature. The study also revealed that this difference is even larger in monetary terms when lifetime energy generation is considered. The present study demonstrated that Random Forests, a machine learning approach to predictive modelling, can handle complex models and can provide models with a higher accuracy compared to statistical modelling approaches. The study recommends the use of solar cell predictive models to improve the accuracy of energy prediction on solar photovoltaic power plants, which in turn assists in energy planning and deployment.

Keywords – Cell temperature; empirical approach; predictive model; random forests; solar photovoltaic power plant

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WATER-ENERGY-FOOD NEXUS FOR CLIMATE CHANGE MITIGATION IN JORDAN

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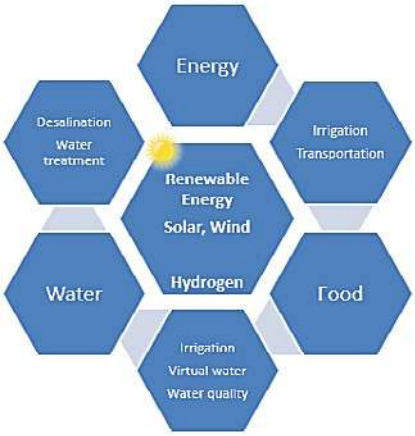
Abstract – In Jordan, the struggle for survival hinges on balancing water, energy, and food security. This arid nation, acutely vulnerable to climate change, holds the Water-Energy-Food (WEF) Nexus approach – weaving water, energy, and food systems into a resilient tapestry. This study delves into Jordan's intricate WEF Nexus, revealing a parched landscape dependent on groundwater, reliant on imported energy, and clinging to agriculture under a harsh sun. However, amidst these challenges lie glimmers of hope: existing initiatives addressing individual sectors and promising interventions leveraging the Nexus approach. The key to a sustainable future is scaling up renewable energy for desalination and efficiency, promoting climate-smart agriculture, and fostering regional resource management. Nevertheless, navigating this complex tapestry demands more than just interventions. Robust governance, empowered stakeholders, and active community engagement are the needles and threads that bind the WEF Nexus together, stitching Jordan's path toward a future where water, energy, and food security sing in harmony. Jordan's narrative is not just about climate vulnerability but about resilience. By embracing the WEF Nexus and its inherent interconnectedness, this nation can transform itself from a thirsty landscape into a beacon of hope, showcasing how climate resilience can develop even in arid regions.

Keywords – Arid region; capacity building; climate change; climate-smart agriculture; desalination; governance; Jordan; regional cooperation; renewables; resilience; sustainability; WEF Nexus



Renewable energy is essential to meet WEF's challenges in Jordan.

ACKNOWLEDGEMENT

This research was supported by the German Research Foundation (DFG). We acknowledge their funding and support for the project titled "Key drivers for technology innovation to improve water, energy, and food security in Jordan".

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WASTE-HEAT RENEWABLE GASIFIER DESIGN THROUGH TAGUCHI'S METHOD AND MANFIS

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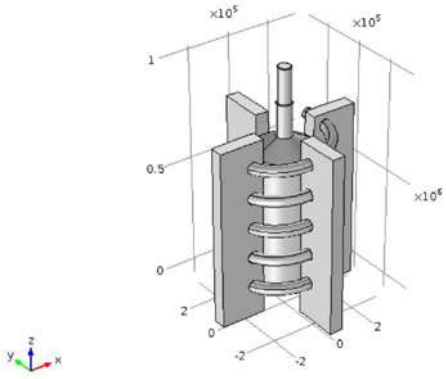
Abstract – Ensuring a global average temperature increase of no more than 1.5 °C is crucial for aligning with the objectives of the Paris Agreement. The Intergovernmental Panel on Climate Change (IPCC) estimates that a 45 % reduction in carbon dioxide emissions by 2030 or a 25 % reduction by the same year is necessary to cap the temperature rise at 2 °C. Failure to achieve this target by 2030 would necessitate substantial subsequent reductions to compensate for the delayed progress toward net zero emissions, potentially incurring higher costs. Elevating the focus on enhancing energy efficiency has emerged as a key strategy in expediting progress toward these climate goals. Hydrogen, renowned for its high efficiency and emission-free combustion, is anticipated to play a pivotal role in this endeavor. Traditionally, gasifiers have served as the conduit for transforming inexpensive fuels like coal or biomass into hydrogen. However, their energy-intensive nature poses a challenge. Addressing this inherent issue, an innovative approach known as the external-heating gasifier has been proposed and designed. The design of the external-heating gasifier represents a quintessential nonlinear and multiple-input multiple-output (MIMO) problem. To achieve optimal performance, the integration of Taguchi's method and inverse-model technology has been employed with a simulation platform developed using the COMSOL Multiphysics software. Initially, Taguchi's method was utilized to determine the minimum number of experiments required for a full-factorial design and identify the most critical factors influencing product performance. Subsequently, an adaptive neuro-fuzzy inference system (ANFIS) was developed with a MIMO–ANFIS architecture. This system was employed to train an inverse model, facilitating the mapping of relationships between each input and output set. In essence, this approach enables the identification of manufacturing parameters that result in optimal performance. To illustrate the efficacy of the proposed method, a simulation study on an existing gasifier is presented.

Keywords – Waste-heat renewable gasifier; Taguchi's method; MIMO problem; MANFIS



Waste-heat renewable gasifier design.

ACKNOWLEDGEMENT

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THE IMPACT OF RED III DIRECTIVE ON THE USE OF RENEWABLE FUELS IN TRANSPORT ON THE EXAMPLE OF ESTONIA

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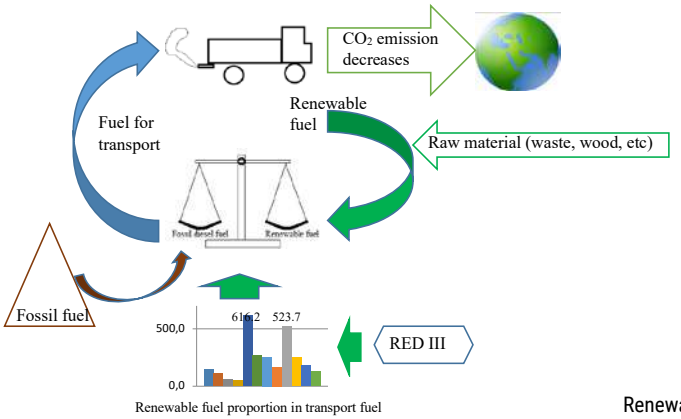
Abstract – Over the past two decades, there has been an increasing use of biofuels worldwide, especially in Europe. The main objective is to reduce greenhouse gas emissions, particularly carbon dioxide (CO_2), from transportation. The regulation of fuels produced from biomass and other renewable sources at the EU level is primarily governed by the Renewable Energy Directive (RED). As of today, RED III directive has come into effect, significantly altering the EU fuel market by 2030. The main change involves an increase in the share of renewable fuels in transport and the non-use of first-generation fuels. Since all EU member states are obliged to comply with the RED III directive, it is essential to assess the current status of each member state in meeting the requirements for transport fuels. Therefore, the aim of this article is to analyse the impact of the RED III directive on the use of renewable fuels in the transport sector. Specifically, it provides an overview of various RED directives' requirements, analyses the shares of renewable fuels in fossil diesel in Estonia under different RED III compliance scenarios, and presents an overview of the situation regarding the use of renewable fuels in Estonia. The article is based on literature review, and fuel share calculations are based on RED III directive calculation methodologies. The results of the study indicate that if the requirement for the share of renewable energy used in transport is 29 %, using only HVO (Hydrotreated Vegetable Oil) to achieve this goal would require replacing 30.3 % of diesel with HVO. In cases where there is a requirement to reduce the greenhouse gas emission intensity of fuels in the transport sector by at least 14.5 % by 2030, the volumetric share of HVO fuel must meet certain criteria based on the raw material. For example, fuel produced from residues must contain a minimal amount of biocomponents. In this context, biologically derived oil is initially used, particularly in food preparation. Subsequently, after its use in food preparation, it is processed into fuel. The article also addresses cases where biogas is introduced as a renewable component in replacing diesel.

Keywords – Biofuel proportion in fossil fuel; biogas; different biofuel proportions; GHG emissions; HVO; raw materials for fuel; Renewable Energy Directive; renewable energy politics in transport



Renewable fuel proportion in transport fuel.

https://doi.org/10.7250/CONECT.2024.044

ANALYTIC HIERARCHY PROCESS ASSESSMENT FRAMEWORK FOR BLOCKCHAIN IN RENEWABLE ENERGY

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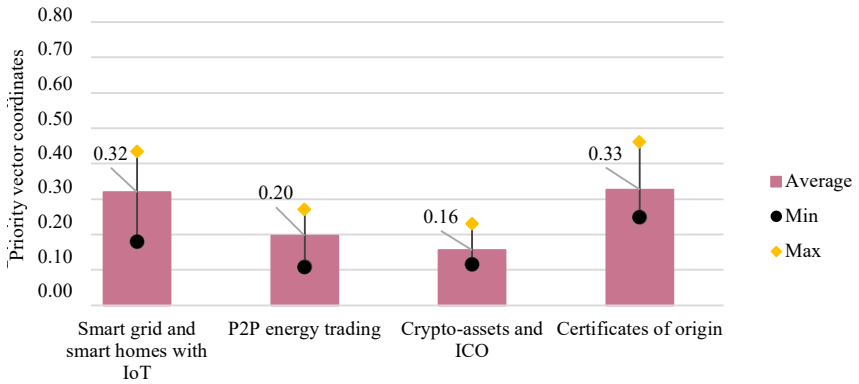
Abstract – The urgency to reach net-zero emissions until 2050 has created a vast interest in innovative technologies for renewable energy sector. At the same time, the need for trusty and unfailing solutions will rise, considering the increasing amount of decentralized and decarbonized energy systems. It has previously been described in the literature that the aforementioned characteristics could be combined by blockchain technology. Therefore, this study focuses on the practical side of the problem – the opinion of industry experts about the use of blockchain technology in renewable energy. By using analytic hierarchy process analysis, the goal of this study is to develop a methodology for the selection of the most appropriate blockchain applications in renewable energy and to identify and evaluate the possible types of use taking into account socio-economic, political and legal, technological and environmental factors. The results of this study highlight the important influence of political, legal and technological factors, such as the involvement of government institutions and possible attacks on the system, but considers the economic factors as the least significant for the introduction and use of blockchain technology in the renewable energy sector. The most promising use cases for blockchain would be associated with reliable and immutable certificates of origin for renewable energy and use in smart grid (including smart metering), smart homes and relevant Internet of Things applications. The use of cryptoassets and initial coin offerings for renewable energy development should be viewed with precaution and willingness to inform and educate considering social factors like public opinion and societies' knowledge on crypto-assets.

Keywords – Analytic Hierarchy Process (AHP); blockchain; net zero; renewable energy



Overall assessment of blockchain application scenarios in renewable energy (n = 6).

https://doi.org/10.7250/CONECT.2024.045

UNVEILING FUTURE OFFSHORE WIND POTENTIAL: A MULTICRITERIA FRAMEWORK FOR SUSTAINABLE DEVELOPMENT

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Abstract – Climate change poses a critical threat to the environment and human societies, prompting a shift towards clean energy sources. Among these sources, offshore wind energy emerged as a promising alternative due to its consistent and strong wind resource availability, coupled with matured technology. However, offshore wind energy being susceptible to the climate change, the efficiency, reliability, and financial viability of the offshore wind farms is location specific. Therefore, the present study introduces a novel framework for identifying suitable regions for offshore wind farm development by considering future projections under the various Shared Socioeconomic Pathway (SSP) scenarios. A weighted multi-model ensemble (MME_{wt}) created using nine Coupled Model Intercomparison Project Phase 6 (CMIP6) climate models was considered for the analysis. The suitability of a location is evaluated considering richness, stability of the resource, risk, and economic factors. CRiteria Importance Through Intercriteria Correlation (CRITIC) multi-criteria technique is used to evaluate the prominence of each factor. Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) is used to determine the suitability of each grid within the study area and their hierarchy. Findings of this study showed that the northwestern and southern regions within the study area are relatively plausible compared to other regions. The proposed methodology built on the theoretical framework of multi-criteria techniques can be extended to other regions and determine the suitability map of plausible wind regions over the specified area for future time periods.

Keywords – Climate change; CMIP6 climate models; multi-model ensemble; multi-criteria techniques; offshore wind energy

https://doi.org/10.7250/CONECT.2024.046

REMOTE SOLAR PARKS FOR BUILDING DECARBONISATION: A LITHUANIAN CASE STUDY ON VIRTUAL PROSUMERS

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Abstract – To reduce the carbon footprint of buildings, the concept of virtual prosumers (consumers who both consume and produce) using remote solar energy parks represents a novel method in Europe. In 2019, Lithuania became the first country in Europe to introduce a digital platform that enables the buying or renting of parts of a remote solar park, making it the first such platform in the world to operate on a national scale. This study examines the effectiveness of this model in Lithuania, assessing the model's success, public engagement, and success factors. The main study focuses on evaluating the impact of remote solar parks on the decarbonization of buildings, particularly through the prism of virtual prosumer participation. Applying a mixed research method, this study integrates both qualitative and quantitative data. The quantitative analysis includes a detailed case study, evaluating the amount of energy produced by two selected remote solar parks in Lithuania, as well as their impact on the carbon dioxide emissions and primary energy use of the two individual houses (a detached house and a unit within an apartment building) connected to these remote power plants. Concurrently, qualitative methods involve analyzing the existing legal and economic frameworks in Lithuania and Europe, which either facilitate or impede the prosumer model, in addition to examining the necessary technological infrastructure. Key findings of this study highlight the potential of remote solar energy parks to significantly reduce the carbon emissions of buildings. This model is especially beneficial for structures where onsite solar energy solutions are impractical. It fosters greater inclusivity in adopting renewable energy, enabling a variety of stakeholders to participate in and benefit from clean energy production. However, the study identifies several major challenges, including regulatory restrictions, the need for infrastructure development, a shortage of developers, state contributions, public awareness, and the creation of a unified platform.

Keywords – Building Decarbonization; clean energy accessibility; digital energy solutions; renewable energy participation

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ENZYMATIC ACTIVITY OF FUNGI FOR HYDROLYSIS OF WHEAT BRAN AND CULTIVATION OF OLEAGINOUS YEASTS

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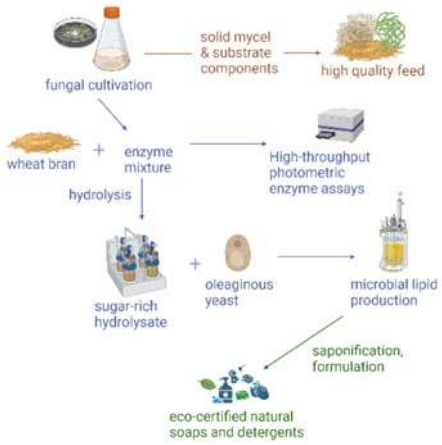
Abstract – Sustainable alternatives to petrochemical raw materials in oleochemical, laundry detergent and personal care industry need to be implemented. Presently, palm oil is the predominant cost-efficient option. While it is a renewable source, it has negative environmental and socioeconomic implications. Therefore, the request for ecologically certified and palm oil-free cleaning agents and household care products is rapidly growing, supported by concepts of waste-free biorefinery. Oleaginous yeasts are currently the most promising source for microbial lipid production. Additionally, wheat bran is a cereal milling by-product, which is available in high quantities and provides an excellent feedstock. Enzymatically generated wheat bran hydrolysate provides an excellent microbial cultivation medium for the sustainable production of high value biological additives. Indeed, wheat bran consists predominantly of lignocellulose, and therefore, of cellulose, hemicellulose and lignin, which can be hydrolyzed by established enzyme systems. Currently, such enzymatic systems are mainly obtained for the market from genetically modified organisms (GMO). This represents a problem because GMO products or process components cannot be included in eco-certified household care formulations. Therefore, innovative GMO-free biotechnological processes need to be implemented, as well as the isolation of novel GMO-free hydrolase enzyme systems. Fungal strains are an interesting source for the efficient screening and isolation GMO-free hydrolases (see the figure). This contribution is part of a project, which aims to use a holistic biotechnological approach to convert mill residues into customized specialty ingredients of eco-certified detergents. The project focuses on three main tasks:



Ideal development of an industrial process producing clean detergents from wheat bran. Created with *BioRender.com*.

1. Investigation of a microbial group of eight Ascomycete fungi.
2. Production of enzymes for hydrolysis of wheat bran.
3. Use of the resulting biomass hydrolysate to cultivate oleaginous yeasts.

Hydrolase producing fungal strains were cultivated on different substrates to investigate their ability to generate specific enzyme systems capable of hydrolyzing wheat bran. The activity of the enzymes was qualitatively and quantitatively characterized to determine the optimal strains for the degradation of wheat bran and suited to implement a large-scale process. Supernatants of different fungal strains cultivations were tested in the hydrolysis step to compare the hydrolysis performances of differently active enzyme mixes. The biomass hydrolysate was used to cultivate lipid generating yeasts to investigate their ability to grow on the microbial cultivation medium.

Keywords – Biomass hydrolysate; cleaning agents; enzymes for hydrolysis; fungal strains; laundry detergents; microbial lipids; oleochemicals; saponification

https://doi.org/10.7250/CONECT.2024.048

ASSESSING THE FEASIBILITY OF CLIMATE POLICIES OF JAPAN, LATVIA AND LITHUANIA TO REACH THE TARGETS OF THE PARIS AGREEMENT

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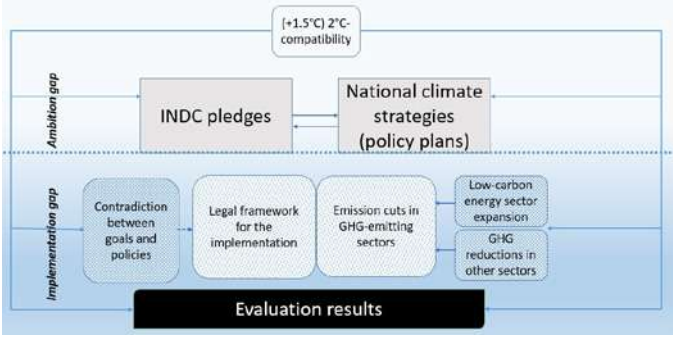
Abstract – The study compares the most recent developments in energy policies of Japan, Lithuania and Latvia as a way to mitigate climate change. Latvia, Lithuania and Japan have all pledged to reach net zero by 2050 but face significant challenges, namely the dependence on energy imports in the form of fossil fuels, as they keep dominating the final energy supply. All three countries have a goal to sharply reduce this dependence, with Lithuania and Latvia even striving to become net energy exporters by focusing almost entirely on renewable energy. Japan, on the other hand, also aims to boost a renewable energy share, yet focuses more on the diversification of imported energy sources. The study attempts to discuss the differing approaches in climate change mitigation in Japan as compared to Latvia and Lithuania. The ambition of each country is estimated by Intended Nationally Determined Contributions (INDCs), the roadmap to reduce the emissions in different sectors as enshrined in the climate strategy of each country, and the penetration of the renewable energy sector, estimating the scope of the ambition and implementation gaps compared to the goals set by the Paris Agreement. The study also estimates the impact of external impacts, namely the COVID-19 pandemic and the Russian invasion of Ukraine in shaping climate change policies. Therefore, this study offers a comprehensive outlook on what needs to be achieved so that all three countries could be role models to follow in the climate policy. All three countries could collaborate on solar power, off-shore wind power, and hydrogen technologies. There have already been joint projects between Japan and the EU on advanced biofuels and the new generation of concentrator photovoltaics. However, there are significant differences regarding the role of ammonia and hydrogen production in the climate change policy strategies of the three countries. Some contributing sectors are left behind and the current climate change strategies, even if properly implemented, may not be 2° C-compatible, let alone 1.5° C-compatible. The policies look even direr for a fair share target, and the implementation gap generally remains wide for the 2024–2030 period.

Keywords – Climate change policy evaluation; COVID-19 pandemic; decarbonisation; INDC; Paris Agreement; renewable energy; Russian invasion of Ukraine



Evaluation graph.

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USE OF SOLAR ENERGY TO INCREASE THE SUSTAINABILITY OF SHARED MICROMOBILITY

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Abstract – This study continues the examination of potential ways to decrease greenhouse gas (GHG) emissions in the urban transportation sector by using shared scooters in Riga. Despite claims by shared scooter operators that these vehicles are environmentally friendly, shared e-scooters contribute an additional 239.9 tonnes of CO_2 in Riga. While energy is not the largest source of CO_2 emissions for shared scooters, it is one factor that could be improved by switching to locally produced green energy. This study revaluates the CO_2 emissions from shared scooters based on an additional year of data. It also analyses the possibility of generating enough energy on-site to provide chargers with PV energy. For this purpose, the study utilizes the last seven years of solar energy data in Latvia to model the potential energy flows that can be used to charge the electric scooters. This data is then combined with information from 3 million scooter trips from the years 2021–2022 scooter seasons, analysing the trips and the energy used during scooter use. It was determined that, on average, 59.6 Wh were used per trip, with a standard deviation of 18.9 Wh. The model was tested with various levels of PV cell areas and energy storage systems to determine the minimum parameters required for the scooters to be provided with enough energy without the need for additional grid charging. The results demonstrate that it is, indeed, possible to provide enough solar energy to ensure continuous charging of the electric scooters for 98.8 % of the cases during the scooter operation period with just 0.2 m^2 of solar cells per scooter. In conclusion, while this approach does not completely offset the CO_2 emissions generated by the short scooter lifespan, it is a step towards greener urban transport. Further research will be carried out to optimize the charging locations for the evaluation of practical PV charging viability.

Keywords – E-scooter CO_2 emissions; energy flow modelling; photovoltaic (PV) charging; renewable energy in transport; shared scooters

ACKNOWLEDGEMENT

This paper has been published within the research project "Use of PV energy for e-scooter charging" carried out within grant program by European Regional Development Fund and Central Finance and Contracting Agency in the research program "Competency Center for Energy", Project number: 5.1.1.2.i.0/1/22/A/CFLA/001.

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A PRELIMINARY EVALUATION OF ALTERNATIVE RAW MATERIALS FOR PELLET PRODUCTION

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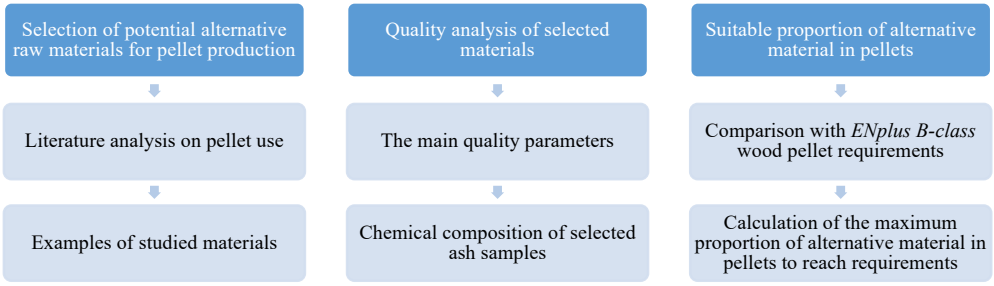
Abstract – The study focuses on alternative raw materials available in Latvia and their possible use in pellet production. Laboratory testing to determine the main quality parameters – the moisture content, the ash content, the calorific value and ash melting temperature – was carried out for 13 alternative biomass sources: pine mix pellets (PMP); pellets of wood shavings, synthetic and textile waste mix (SSK); hogweed (*Heracleum sosnowsky*, HW); the full plant of *Solidago canadensis L.* (SC); the full plant of *Solidago canadensis L.* outgrown (SCO); mowed grass from the municipality (MGM); mowed grass from the garden (MGG); chamomile full plant without stems (CF); hemp without roots (*Cannabis sativa L.,* HWR); hemp stems (*Cannabis sativa L.,* HS); hemp leaves with seeds (*Cannabis sativa L.,* HLS); spent grain (SG); damaged spent grain (DSG). The testing and determination of results were carried out according to the methodology set out in ISO standards regarding solid biofuels. The obtained results were compared to the quality parameters defined in *ENplus* certification for *B-class* wood pellets in requirements for producers. Additional analysis of chemical composition was carried out using XRD *(X-ray diffraction)* and SEM-EDX *(scanning electron microscopy – energy dispersive X-ray spectroscopy)* for the ash of two selected materials – SC and HLS – to gain an insight into possible combustion issues that can occur during the use of these materials. The main issue highlighted by the results is the ash content of alternative materials, which ranges from 1.34 % to 11.27 %. The other significant issue is the necessity to improve the ash deformation temperature, which was below 1100 °C for 5 of the studied materials. Considering this, an algorithm was developed to determine the optimal proportion of alternative material and wood in pellets to achieve a quality comparable to at least *B-class* wood pellets. The study offers a direction for further research to successfully develop new pellets that could be later used in existing boiler systems, reducing the dependence on wood in pellet production. A discussion on the use, quality and development of alternative material pellets is offered to promote the significance of the topic.

Keywords – Alternative biofuels; ash content; ash melting; biomass pellets; calorific value; chemical composition; energy; moisture content



The algorithm of the study.

ACKNOWLEDGEMENT

This research is funded by the Latvian Council of Science, project "Alternative biomass knowledge for transition towards energy independence and climate targets (bioenergy Observatory)", project No. lzp-2022/1-0414.

FLPP FUNDAMENTAL AND APPLIED RESEARCH PROJECTS

Bioenergy Observatory

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NATURE-INSPIRED WIND FARM LAYOUT OPTIMIZATION: HARNESSING SMART PATTERNS FOR SUSTAINABLE ENERGY

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Abstract – This research investigates the transformative realm of wind farm layout optimization, with a specific focus on harnessing the efficiency of bio-inspired patterns. The positioning of wind turbine plays a vital role in maximizing the energy output of a wind farm. If a wind turbine is placed in the wake region of the upstream turbine, the energy produced by the downstream turbine is reduced. Hence, it is imperative to place turbines in such a way that effect of the wake is minimum on a performance of turbines. The conventional grid-based approaches, commonly employed in wind farm layouts, face limitations in capturing the inherent complexity of wind flow dynamics, especially in varied terrains. In contrast, bio-inspired layouts, inspired by patterns observed in natural ecosystem, offer the promising results over the conventional Grid based approach. Our investigation involves the development and implementation of a novel bio-inspired wind farm layout positioning pattern. In the proposed approach, various nature inspired patterns, such as honeycomb and sunflower seeds pattern, is explored for the turbine positioning. Further, the approach includes the modelling of wind behaviour in terms of both uniform wind speeds and variable wind speeds originating from all directions. The modified passing vehicle search (mPVS) optimization algorithm is used for optimizing the wind turbine placement. The results are obtained for the different wind scenarios and compared with the available results in the literature. The anticipated outcomes of this research include a deeper understanding of the potential benefits and challenges associated with bio-inspired wind farm layouts. The findings aim to contribute valuable insights into optimizing wind turbine placements, maximizing energy capture, and fostering sustainable practices in the wind energy sector. Results show that the turbine positioning in the proposed bio inspired pattern produces higher power output (6 %) compared to the conventional grid-based approach. Hence, it can be concluded that the approach present in this study can assist wind farm designers and developers in optimally placing turbines for better performance.

Keywords – Energy system optimization; nature inspired pattern; wake deficit; wind farm layout; wind farm layout optimization

https://doi.org/10.7250/CONECT.2024.052

EXPLORING THE POTENTIAL OF RENEWABLE ENERGY TO ENABLE GREEN HYDROGEN PRODUCTION FOR A SUSTAINABLE FUTURE

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Abstract – Amidst intensifying concerns about greenhouse gas emissions, the imperative to transition towards sustainable energy solutions is paramount. Renewable energy sources (RES) provide a promising avenue, especially in hydrogen production. In this context, the emergence of 'green hydrogen' is pivotal. Green hydrogen is a concept produced using RES like solar and wind energy to power the hydrogen production process. Unlike conventional methods emitting carbon dioxide, green hydrogen is generated through water electrolysis using clean energy. India relies on coal for around 70 % of its energy needs, leading to a 29 % rise in carbon emissions from 2015 to 2022. Green hydrogen is a potential alternative solution to address the increasing energy demand and the depletion of fossil fuels. Using wind energy for water electrolysis emerges as a suitable method for green hydrogen production. Therefore, the present study assesses the potential of hydrogen production using the wind energy resources in five selected locations in India using ERA5 hourly wind data. The investigation further explored the characteristics of wind speeds at these locations using average wind speed, Weibull parameters and wind rose analysis. Using the SUZLON S95 wind turbine, power output and annual energy generation at each location were estimated. Further, the annual hydrogen production and required storage capacity at each location were estimated. The results showed a power generation of 891 kW in location Una and 895 kW in Mandvi. Finally, the amount of carbon emissions mitigated due to the use of wind energy sources instead of conventional sources for H_2 production is calculated.

Keywords – CO_2; electrolysis; green hydrogen; hydrogen storage; mitigation; wind energy

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CURRENT TRENDS AND SOLUTIONS FOR PORT DECARBONISATION: A SYSTEMATIC LITERATURE REVIEW

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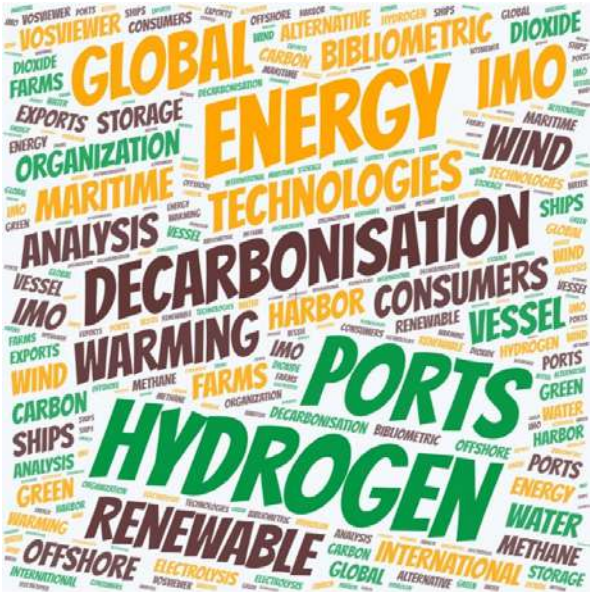
Abstract – The energy sector is changing rapidly today. Global warming and other environmental challenges contributed to several international agreements aimed at fostering fossil-to-renewables debt. Decarbonisation is undoubtedly a challenge, but at the same time a potential for development. The energy sector is made up of many sectors that have their own specificities, constraints, and opportunities. This study reflects progress in the decoration of ports. Ports are places that often bring together energy consumers of different levels and types – water and land transport, as well as consumers of thermal energy, electricity, and fuels. The bibliometric analysis method is used in publication to analyse current trends. The results show that despite the existing challenges and historic delays with the entry of renewable energy sources into ports, scientific progress is prepared to offer solutions to decarbonise port energy consumers as well. These studies reflect that hydrogen technologies are the most prospective solution, but many aspects and links need to be considered to ensure the transformation of the sector.

Keywords – Bibliometric analysis; decarbonisation; energy consumers; hydrogen; ports; renewables



Keywords-based visualization diagram of port decarbonisation.

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CHALLENGES OF UNDULAR JUMP MODELLING

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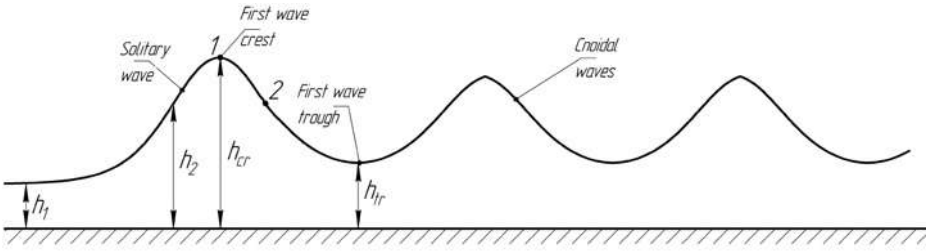
Abstract – The study of open channel flow hydraulics extends beyond supercritical and subcritical flow states to include a distinct state known as near-critical flows. This category encompasses various hydraulic phenomena, with some of the most notable being solitary waves, cnoidal waves, and undular jumps. This paper specifically addresses the phenomenon of undular jumps, providing a brief overview of its characteristics and discussing instances of undular jump formation in natural rivers settings and during the operation of various hydraulic structures. When there is a sudden change in flow depth from a lower level to a higher one, it typically leads to a sudden increase in the water surface, known as a hydraulic jump. However, if the jump is relatively small, meaning the depth change is minor, the water does not rise noticeably and abruptly. Instead, it will traverse from the lower to the higher stage through a sequence of gradually diminishing undulations that extend over a considerable distance. Such phenomenon is called an undular jump (see figure)



Scheme of undular jump.

The occurrence of undular hydraulic jumps can be observed in various open channels such as irrigation and water supply channels, beneath vertical sluice gates, within estuaries during specific tide periods, and in narrow or shallow passages affected by strong currents. Additionally, this phenomenon often manifests downstream of low drop structures or in transitional zones from steep to gently sloping channels. In channels where undular jumps occur, waves with significant amplitudes develop and travel downstream of the jump. Accounting for the propagation of these downstream free-surface waves is essential for canal design and natural channel maintenance. The wave height serves as a crucial design parameter that dictates the necessary sidewall height of the canal. In natural channels, the embankment height must exceed the crest of the free-surface undulations to prevent overtopping and subsequent erosion, which could ultimately lead to bank destruction. Moreover, the propagation of free-surface waves may subject downstream canal structures, such as gates, locks, and weirs, to additional impact loads, perturbations, and vibrations.

In recent years, different scientists have made various attempts to investigate and describe this phenomenon using physical, mathematical and computer modelling. However, this phenomenon has a number of peculiarities that are not always taken into account. An objective of this article is to present the particularities of different type of undular jump modelling and to compare the obtained results.

Keywords – Environmental impact; hydraulic regime; modelling; undular jump

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ELUCIDATING STAKEHOLDER PRIORITIZATION FOR SUSTAINABLE OFF-GRID RENEWABLE ELECTRIFICATION USING THE FUZZY AHP-GPESTLE FRAMEWORK: A COMPREHENSIVE ANALYSIS

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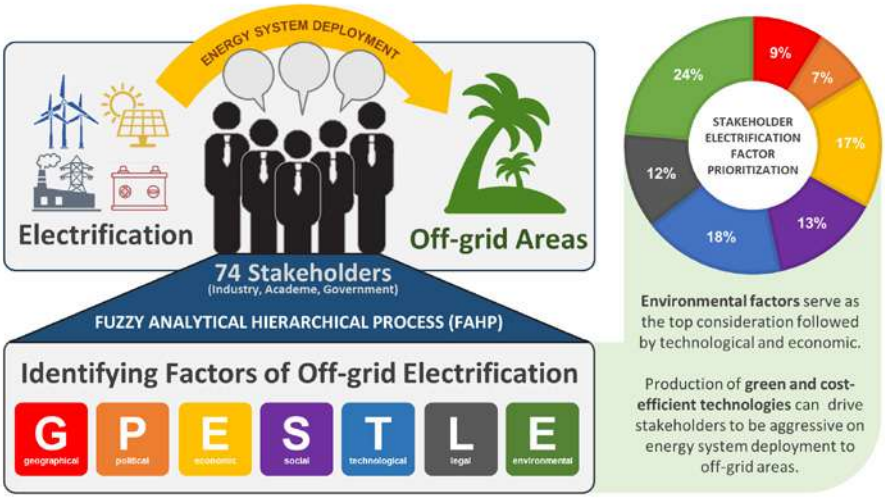
Abstract – Poverty has been linked to the reality of the world's developing countries, especially in farflung rural areas, where the lack of energy access plays a significant role in the misery of the poor and disadvantaged people. To achieve universal access to energy, the role of rural electrification was emphasized, and off-grid small-scale electricity generation from renewable sources was expected to be a promising solution. However, in the Philippines, where off-grid island communities are scattered along its archipelago, the deployment of such systems in rural areas is still a challenge among stakeholders due to the consideration of various conflicting factors that may put the potential economic gains and other social and environmental benefits at risk. To better understand the multifaceted nature of off-grid energy system sustainability through the perspective of its stakeholders, the Fuzzy Analytical Hierarchy Process (FAHP) was used to determine their most prioritized factors in determining the viability and sustainability of such systems following the GPESTLE framework. This provides a comprehensive and more relevant approach to performing sustainability analysis by looking into the geographical (G), political (P), economic (E), social (S), technological (T), legal (L), and environmental (E) dimensions of these assemblies. The prioritization of 74 expert stakeholders, coming from the industry, academy, and government institutions, has been elucidated by having them perform pairwise comparisons among the various GPESTLE criteria through a survey. Using FAHP, prioritization or weights were already generated per G-PESTLE criterion and sub-criterion. It was found out that among the three institutions, the industry players have the lowest environmental prioritization and can be increased by developing them with cost-efficient renewable technologies. The availability of technology manufacturers and transportation accessibility has been the main consideration in ensuring the reliability of the system's operation. Minimizing LCOE and increasing the people's capacity to pay should also be a priority to secure the project's financial viability. The presence of a community comprehensive land use plan has also been highly favored among developers, which can allow faster processing of permits on the use of indigenous resources and agricultural lands. With these findings, this framework aims to guide policymakers to properly address the challenges of islands lying low in prioritization due to problems on certain sustainability factors. These insights can be relevant in the drafting of a transitional framework on the renewable electrification of off-grid islands, which were usually left out or minimally given attention in the national electrification plans of governments.

Keywords – AHP; PESTLE; renewable energy; sustainability



An overview of the combined Fuzzy AHP – GPESTLE methodology used in this study.

ACKNOWLEDGEMENT

This work is financially supported by the "ElectriPHI: Systematic, Multi-disciplinary, and Data-driven Electrification Planning in Off-Grid Islands" program (IntensiPHI project) funded through the Emerging Interdisciplinary Research Program (OVPAA-EIDR-C09-01) of the University of the Philippines Office of the Vice President for Academic Affairs (UP OVPAA).

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PH-OPTIMIZED BIOMETHANE PRODUCTION: EVALUATING CARRIER MATERIALS FOR EX-SITU BIOMETHANATION

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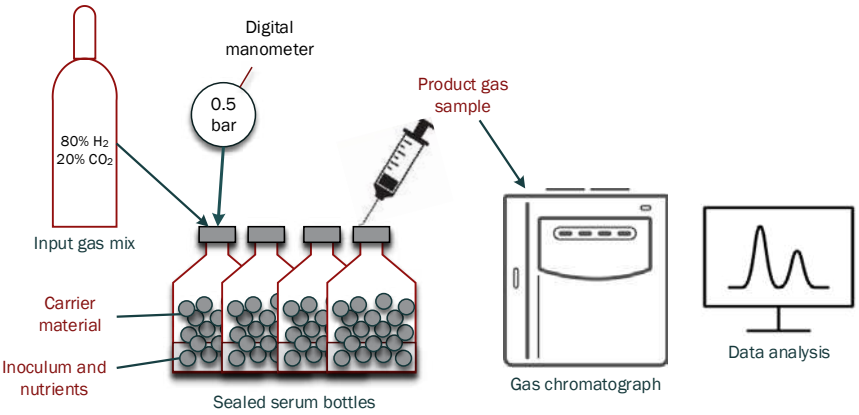
Abstract – Choosing the appropriate carrier material for ex-situ biomethanation is a critical factor to consider when developing biogas upgrading technologies. The chosen material for biomethanation in a biotrickling filter reactor functions as a substrate that immobilises microorganisms, which act as catalysts in the reaction for producing biomethane. This study conducted experiments on waste-derived materials, including glass foam and vulcanised wood ash material, in addition to polyurethane foam and expanded clay pellets. Pretreratment of wood ash was done to lower the pH level of material. The manometric test measured the rate of CH_4 generation by quantifying pressure fluctuations. The validity of these results was confirmed by analysing product gas samples using a Shimadzu Nexis GC-2030 gas chromatograph, which was equipped with two parallel lines, a flame ionisation detector (FID) and a thermal conductivity detector (TCD). In order to enhance the biomethane concentration in the end product, two strains of methanobacterium alcaliphilum were evaluated alongside biogas sludge as the inoculum. These strains of microorganisms are methanogens that utilise hydrogen and can thrive in a high pH environment. Thus, they have the potential to demonstrate improved biomethane production outcomes when a vulcanised wood ash filter is used as the carrier material.

Keywords – Biomethanation; biogas upgrading; carrier material; gas chromatography; methanobacterium alcaliphilum; vulcanized wood ash



Methodology for biomethanation experiment.

ACKNOWLEDGEMENT

This work was supported by the European Social Fund within the Project No. 8.2.2.0/20/I/008, "Strengthening of PhD students and academic personnel of Riga Technical University and BA School of Business and Finance in the strategic fields of specialization".

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SUITABLE SOFTWARE FOR THE STUDY OF COMBUSTION PROCESSES IN BOILERS

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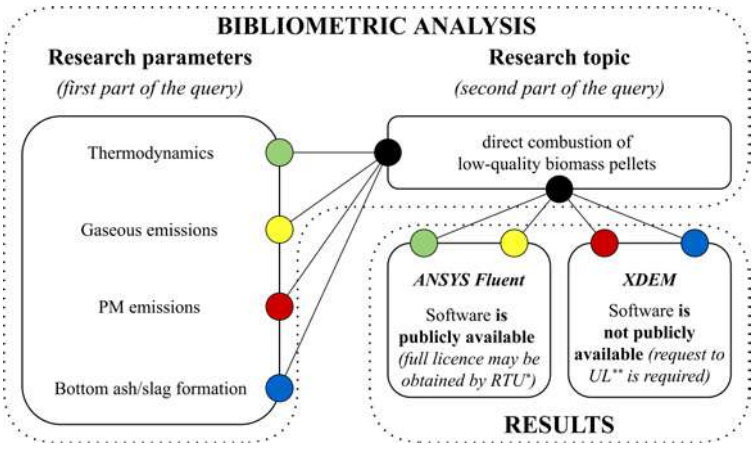
Abstract – Diversification of energy resources is a current objective that several countries want to achieve, including in northern Europe. Demand for wood fuels is increasing in Latvia, reflected in consumer expenditure. Using low-quality biomass (LQB) to produce fuel pellets for stabilisation and diversification is possible. LQB pellets can theoretically and practically be used in low-capacity solid fuel boilers to provide different types of individual heating systems with an alternative energy source. Before starting mass production of LQB fuel pellets, it is necessary to clarify the properties of the raw materials. Any fuel study shall be divided into two phases: determination of the parameters of the fuel or raw material (calorific values, moisture content, and ash content) and analysis of the combustion process. The combustion process can be studied in two ways: experimentally and by mathematical modelling. Knowing the parameters that would need to be clarified during the study of the LQB fuel pellets combustion process (thermodynamics, gaseous emissions, PM emissions, bottom ash, and slag), the authors have set the goal of clarifying the software applied to mathematical modelling of these parameters. A bibliometric analysis method was chosen to identify the software. The bibliometric analysis was carried out in the *Scopus* database. As a result, two software were identified: *ANSYS Fluent* software is suitable for modelling thermodynamic processes and gaseous emission streams. At the same time, *XDEM* software is ideal for modelling particle streams and ash/slag generation. This software will be used in future studies.

Keywords – Bibliometric analysis; biomass pellets; combustion process; modelling; software



Bibliometric analysis execution diagram and results algorithm
(* – Riga Technical University, ** – University of Luxembourg).

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ASSESSING THE APPLICABILITY OF SOLAR THERMAL TECHNOLOGIES FOR INDUSTRIAL TEA DRYING

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Abstract – Most process heat being used for various industrial applications is supplied from fossil fuels. Coal, gas, and wood fuel are the most used heat resources which usually power steam boilers for production of heat used in a wide range of industrial processes. Since economic growth is largely linked to industrial production, it implies that a shift towards use of clean energy technologies in industries is crucial to meet the rising demand of process heat while cutting down carbon emissions to mitigate climate change. Solar thermal systems have over the past years shown potential as a practical alternative to fossil fuels for production of heat for several applications, including water and space heating, industrial process heating and electricity generation in thermal power plants. This study seeks to assess the feasibility of employing solar thermal technologies for drying purposes at Tingamira-Tanganda Tea estate in Zimbabwe. Systems advisor model (SAM) was applied to simulate performance of linear Fresnel (LF) and parabolic trough (PT) solar thermal technologies for industrial tea drying. Information on daily heat demand, required process temperatures and current heat sources were obtained to inform the design process of the proposed solar thermal systems. LF system exhibited better techno-economic performance. It requires a smaller collector area (360 m^2) with a lower initial capital cost which is about 8 % cheaper. Moreover, it produces higher annual energy at lower levelized cost of heat for solar multiples higher than 1. Carbon footprint of the factory would be reduced by about 114 tonnes CO_2 annually. Sensible thermal energy storage technology can be considered for back-up heat and heat recovery.

Keywords – Process heat; solar multiple; solar thermal; thermal energy storage

05

LOW CARBON DEVELOPMENT AND BIOECONOMY

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A NOVEL GE-MACKINSEY MARKET APPROACH: INVESTMENT OPPORTUNITY FOR THE BIOPOLYMER PACKAGING MATERIALS

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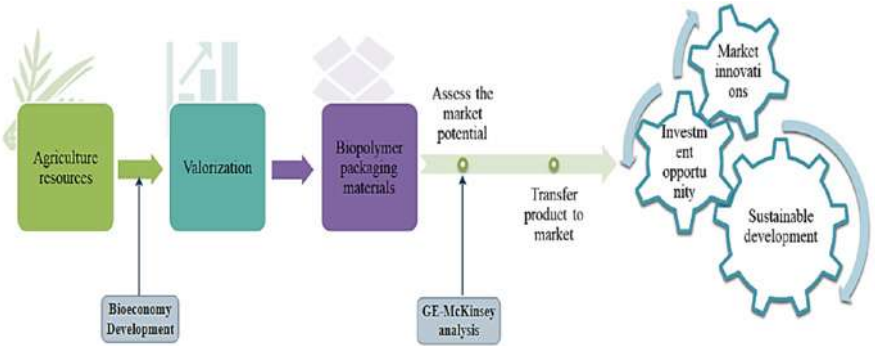
Abstract – Sustainable development in agriculture seeks to implement a robust bioeconomy strategy by valorizing agricultural resources into value-added products. Compared to primary biomass use, using agriculture residues and wastes can help to achieve higher reductions in GHG emissions and lower feedstock costs. Bioeconomy has substantial potential for high-value products such as biopolymers, pharmaceuticals, and food and feed additives. Low-value applications like bioenergy, biofuels, and bulk chemicals have a weak potential for bioeconomy development. However, high value-added products, including biopolymers, require an equal focus as other products in the bioeconomy value pyramid that can lift the market to elevate sustainable bioeconomy development. A successful transition through radical innovations must be justifiable, with economic, environmental, and social benefits primarily promoted by stakeholders, businesses, or government organizations. One of the core options would be to know the market potential of the biopolymer products. Here, a methodology for decision-making to evaluate four existing biopolymer packaging materials (cellulose, PHA, PLA, and starch) in the EU market has been developed using the GEMcKinsey Nine-Box Matrix, considering market attractiveness and product competitive advantage. Market innovations can be fostered by integrating the resource availability and technology advancement indicators to the methodology steps. The methodology considers sustainability advantages for the agriculture sector and promotes the strategic commercialization of biopolymer packaging materials. Product-specific indicators are used to evaluate the market attractiveness and product competitive advantage. The research findings show that PLA biopolymer packaging material has the highest potential for commercialization. The application of this methodology and its results provide a justifiable way of determining the investments in value-added products and allow investors to make the right decision-making choice for bioplastic packaging materials, ensuring their sustainability and profitability in the market.

Keywords – Agriculture resources; bioeconomy; biopolymer packaging materials; commercialization; GE-McKinsey matrix



Market analysis for biopolymer packaging materials.

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CURRENT CHALLENGES AND FUTURE OUTLOOK: TRENDS AND FORECASTS IN THE MARICULTURE SECTOR

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Abstract – Aquaculture, defined by the United Nations Food and Agriculture Organization (FAO), encompasses the farming of aquatic organisms for food production, offering a promising solution to global food security challenges. Over the past three decades, global aquaculture production has consistently grown at approximately 8 % annually, outpacing other major animal food production sectors. Mariculture, a subset of aquaculture focusing on marine organisms, has emerged as a critical component, accounting for a third of global aquaculture production.

However, mariculture faces numerous challenges, including environmental impacts, reliance on wild inputs, and concerns about genetic interactions with wild populations. Biotechnological advancements offer potential solutions but must be balanced with considerations of ecosystem health and societal impacts.

Integrated mariculture techniques and bioremediation approaches present opportunities to mitigate environmental impacts, but legislative frameworks and monitoring procedures are essential for ensuring compliance and minimizing adverse effects. Collaborative efforts between the public and private sectors are crucial for advancing sustainable practices and unlocking the full potential of the mariculture sector.

In conclusion, addressing the challenges facing mariculture requires a comprehensive approach that prioritizes environmental sustainability, regulatory compliance. By embracing sustainable practices and fostering collaboration, the mariculture sector can navigate its challenges and contribute to global food security in a responsible and resilient manner.

Keywords – Aquaculture; mariculture; sustainable practices; environmental impacts; biotechnological advancements; food security; global trends

https://doi.org/10.7250/CONECT.2024.061

GREEN WHEELS, GREENER WALLETS: ECONOMIC VIABILITY OF LAST-MILE DELIVERY FLEET ELECTRIFICATION IN CASE OF LATVIA

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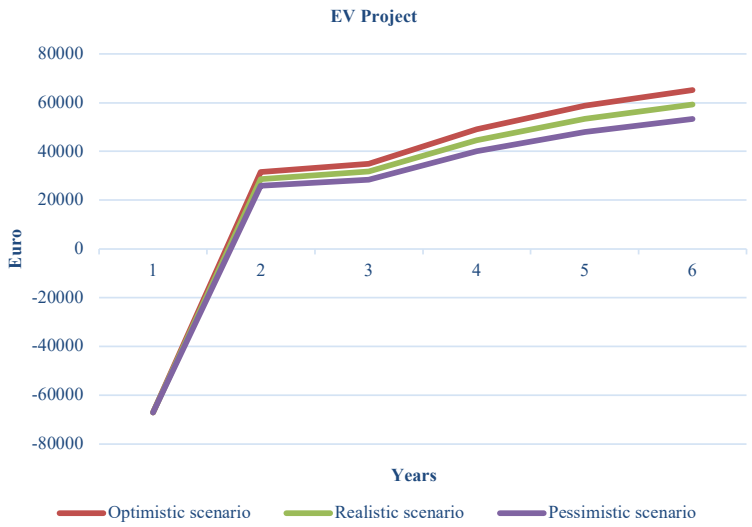
Abstract – The analysis of internal combustion engine vehicle (ICEV) usage habits in *DPD Latvija* and the study of the specifics of its last-mile delivery transport business will allow to understand whether electromobility solutions can make the company more efficient. The question addressed in the research is whether the electrification of the delivery vehicle fleet can reduce transport expenses for the company and under what conditions. For estimation of direct and indirect costs of transport acquisition and usage, Total Cost of Ownership (TCO) is used. The company's daily operation parameters and technical data of the used vehicles VW e-Crafter and VW Crafter 35 Kasten/long base are considered in the study. Net Present Value (NPV) and Internal Rate of Return (IRR) calculation methods are used for analyzing the investment project. The expense of the creation of electrical vehicle charging infrastructure is not considered because the company's daily routine allows to cover all charging processes overnight by using domestic sockets together with Mode 2 chargers. All technical data and calculations were made for deliveries in a city cycle. In financial terms of owning delivery transport, the company is using a 5-year operational lease with 0 % first payment. The obtained results in terms of TCO comparison showed a slight advantage by using EV after 5 years of last-mile delivery service per 1 vehicle – 706.98 euro at 31 200 km a year or 100 km in the working day of 6-day working week (156 000 km in 5 years is under 160 000 warranty condition). The calculation is performed for *DPD Latvija* 213 ICE vans of a total 240-vehicle fleet.



Three different scenarios were considered in the study.

Results of NPV, NPVI, and IRR with a comparison rate of 10.6 % for EV case clearly show a sufficiently good return. The Net Present Value of the solution is 89271.92 euro and the internal rate of return is 48.05 %. The study proves that the electrification of the last-mile delivery company's fleet is economically justified within 5 years. In the process of electrification, the company will reduce its expenses by 1.45 %, which increases the net annual profit by 0.13 %. The main conclusion is that the company will not incur losses by switching to an environmentally friendly vehicle, the capital investment in a realistic scenario pays off already from the 3rd year. Nevertheless, the authors of the study recommend evaluating delivery vehicles with higher driving range parameters, because during peak delivery times and cold seasons, the company may experience unplanned downtime and expenses due to the need for additional charging time at public charging networks on the road, which could lead to financial losses and need for TCO calculation corrections.

Keywords – DPD; E-mobility; fleet electrification; last-mile delivery; total cost of ownership (TCO)

https://doi.org/10.7250/CONECT.2024.062

ENVIRONMENTALLY FRIENDLY PROCESSING OF FORESTRY BIOMASS SIDE STREAMS – CONIFEROUS NEEDLES AND GREENERY

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Abstract – Replacement of fossil materials with renewable biomass is essential to address climate change challenges and implement bioeconomy as essential element of sustainable development model. A significant source of biomass is forestry. However, besides timber, significant amounts of forestry biomass side streams are formed, and from circular bioeconomy perspective full utilisation of valuable resources is requested. One of the side products of coniferous tree processing are needles and greenery, and as these trees are dominant in Northern regions, a full use of their biomass can provide significant input to replace fossil resourcebased substances and materials. Coniferous tree needles and greenery are a rich source of biologically active substances with wide application potential as resource for biopharma industries, food and feed supplements, and materials for diverse application. Traditionally, for extraction of biologically active substances from coniferous needles and greenery, toxic and hazardous solvents, such as organochlorine and hydrocarbon solvents, have been used. The aim of the present study is to develop possibilities to use green chemistry approaches for coniferous needle and greenery extraction and following biorefinery to obtain biologically active components. For extraction of coniferous needle and greenery, green solvents have been tested, as well as so called intensive extraction methods have been used. The yield of extracts depends on extraction temperature, duration, solvent and other factors and optimal extraction conditions provide possibilities to obtain yield of extracts higher than use of traditionally used solvents. As a powerful tool to increase yields of extracts so called intensive extraction methods, such as treatment with ultrasound, microwaves, accelerated solvent extraction have been studied. The obtained extracts were characterised using gas chromatography with mass spectrometric detection, liquid chromatography and other methods. Possibilities of biorefinery of obtained extracts to isolate groups of substances or individual substances have been discussed.

Keywords – Analysis; coniferous needles and greenery; extraction; Green Chemistry

ACKNOWLEDGEMENT

This research was funded by the Rural Support Service of Latvia project "Full-cycle processing of green biomass from skewers to produce high-value feedstocks for the chemical and pharmaceutical industries" (Nr: 23-00-A01612-000007).

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CARBON FARMING: A SYSTEMATIC LITERATURE REVIEW ON SUSTAINABLE PRACTICES

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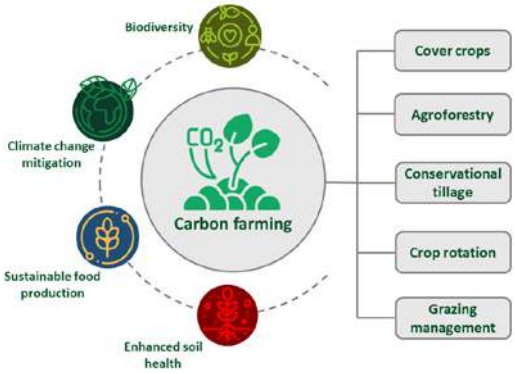
Abstract – The European Union (EU) aims to reduce its greenhouse gas emissions by at least 55 % by 2030. As the goal for 2030 is already set, and now it is challenging to reach a 55 % reduction of greenhouse gas (GHG) emissions, the goals will become more challenging as the EU plans to reach climate neutrality by 2050. As the EU's Climate goals become more ambitious, the countries have to adapt and find more potential ways to decrease GHG emissions in all sectors. One of the biggest contributors to GHG in the EU is the agricultural sector. One of the potential ways to reduce GHG emissions in the agricultural sector is carbon farming. Carbon farming is a sustainable agricultural approach designed to sequester carbon dioxide from the atmosphere and mitigate climate change. By employing regenerative practices, carbon farming enhances soil health, promotes biodiversity, and reduces GHG emissions. Carbon farming emerges as a key player in the global effort to combat climate change. The integration of carbon farming practices into agriculture not only can ensure sustainable food production but also underscores the critical role agriculture can play in sequestering carbon and building resilience against the challenges posed by a changing climate. Even though carbon farming has the potential to decrease GHG emissions from the agricultural sector and sequester carbon, there are still knowledge gaps on how to assess carbon farming practices and their potential carbon sequestration, as well as which practices the farmers could use to gain the best possible outcome based on the carbon practice feasibility and sustainability. The study aims to develop a systematic literature review that assesses the main carbon farming practices and their potential to help reach climate goals and contribute to climate change mitigation.

Keywords – Agriculture; carbon sequestration; climate change mitigation; systematic literature review.



Carbon farming practices and their potential benefits.

ACKNOWLEDGEMENT

This research has been done within Fundamental and Applied Research Project "Carbon farming Certification system: The transition towards result-based agriculture sector (CarbFarmS)", project No. lzp-2023/1-005, funded by the Latvian Council of Science.

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IMPACT OF EU FUNDING ON LATVIAN AQUACULTURE: PRODUCTIVITY, COMPETITIVENESS AND PERSPECTIVES

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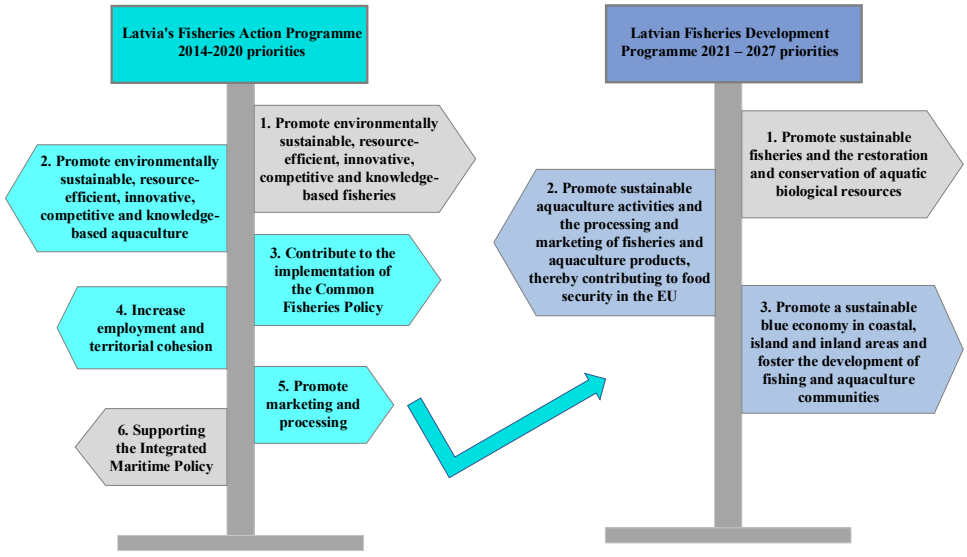
Abstract – The eligibility period for the 2014–2020 Operational Programme of the EU's European Maritime and Fisheries Fund (EMFF) closed at the end of 2023. The allocation under the EMFF to the Latvian fisheries and aquaculture sector was more than €130 million, distributed in accordance with Latvia's Fisheries Development Action Programme 2014–2020. The primary objective of this research is to analyse the outcomes attained through the allocation of funding and ascertain the extent to which Latvian aquaculture productivity has augmented, alongside its competitive standing and sustainability across both domestic and global markets. This includes integrating technological advances and innovative practices into existing aquaculture companies, as well as providing funding for projects that stimulate the creation of new aquaculture companies, such as the promotion of community-led local development strategies and the collection and availability of sector-specific data that could indirectly contribute to the development of the sector. A cost-effectiveness analysis was conducted to ascertain the anticipated return on the EU funding provided and evaluate the amplified growth prospects within the aquaculture sector. The results show that the performance indicators and targets set for the aquaculture sector as part of the funding allocation are vague and consequently do not lead to a recognisable increase in aquaculture productivity or added value.

Keywords – Aquaculture; European maritime and fisheries fund; economic impacts; funding allocation; productivity growth



Priorities set out in the Latvian Fisheries Development Programmes, under which EMFF funding is allocated.

https://doi.org/10.7250/CONECT.2024.065

ORGANIC OR NON-ORGANIC AGRICULTURE: COMPARISON OF ORGANIC AND CONVENTIONAL FARMING SUSTAINABILITY

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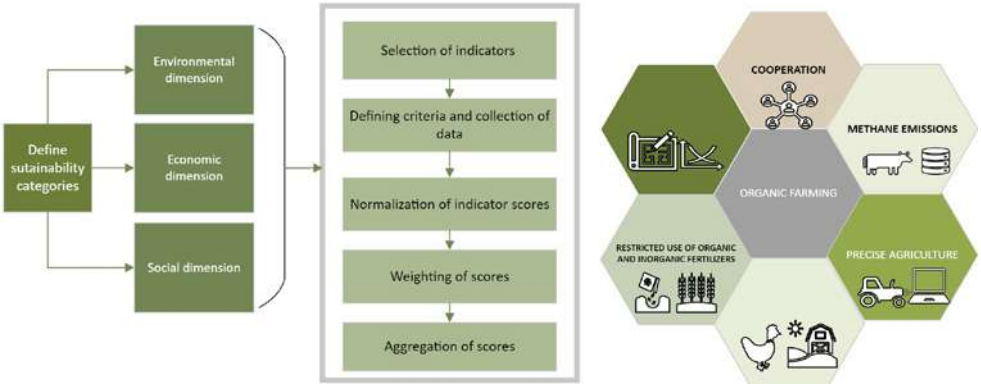
Abstract – Reduction of the level of greenhouse gas emissions produced by the sector of agriculture is one of the serious issues across European Union. The dairy industry is responsible for generating a significant amount of emissions from enteric fermentation, manure and long-term storage. The amount of emissions produced depends highly on such factors as livestock feeding and manure management systems, feed intensity and quality. Farms that have high milk yield also produce more liquid manure, leading to an increase in overall emissions from manure management. Organic farming has been valued as one of the most suitable solutions to conventional agriculture for the achievement of climate goals. Organic farming can be described as a farming approach based on prevention, ecological processes, and the restriction of pesticides. Restricting pests and lower yields can have a negative impact on production costs and revenues. However, organic farming has lower operating costs and higher product costs, which can increase overall incomes. This research aims to evaluate the environmental, economic and social dimensions of conventional and organic farming, comparing their integral environmental, economic and social sustainability. The core element for the sustainability assessment is the construction of the composite sustainability index using data for scientific literature, reports and statistics.

Keywords – Composite sustainability index; economic dimension; emissions; environmental dimension; social dimension



Methodology of the study.

06

ENVIRONMENTAL AND ENERGY POLICIES AND FRAMEWORKS

https://doi.org/10.7250/CONECT.2024.066

USE OF THE NATIONAL CLIMATE AND ENERGY POLICY SIMULATION TOOL IN THE POLICY MAKING PROCESS

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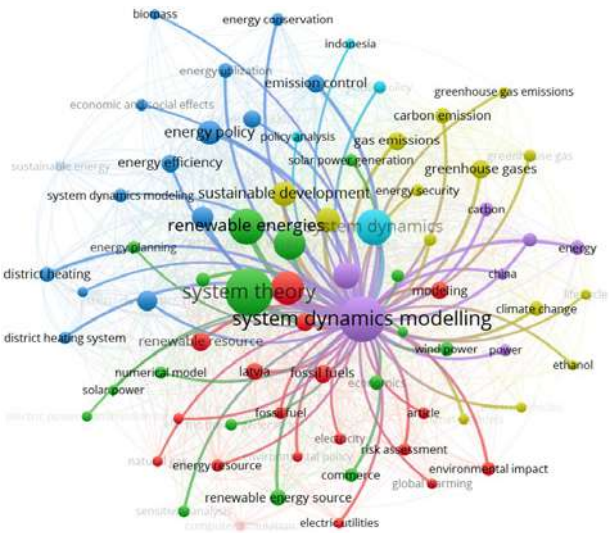
Abstract – Energy transition towards CO_2 neutral energy systems is challenging as the national energy policy depends on numerous factors. In system dynamics approach these factors are identified as causal and feedback loops with lock-ins, as a result constituting stock-and-flow structure. Such kind of structure is used in different simulation tools. This study analyses the use of the Latvian national climate and energy policy simulation tool in the policy making process. As a hypothesis of the study was set that the simulation tool, which is based on the principles of systemic thinking (explaining causal relationships) and an easy-to-use user interface, significantly improves the national energy and climate policy making process. Accordingly, to verify the hypothesis, the task was to evaluate the use of the national climate and energy policy simulation tool in the policy-making process. For the evaluation, the relevant literature was reviewed: climate and energy policy goals, policies and legislation in the European Union and Latvia; approaches to modeling national climate and energy policies, including optimization models, simulation models; the use of simulation models in the modeling of national climate and energy policies; the use of system dynamics models in the modeling of national climate and energy policies. Besides using the systemic thinking approach in the process of creating national climate and energy policies, the user experience in building simulation tools was used. Based on the literature analysis, improvements to the interface of the national climate and energy simulation tool developed by the RTU, Institute of Energy Systems and Environment were made and developed training material for the use of the simulation tool based on explaining the causal relationships built into the model.

Keywords – Energy transition; policy making; renewable energy; simulation tool; system dynamics modeling



System dynamics modelling interconnection with energy transition.

https://doi.org/10.7250/CONECT.2024.067

WHAT TO DO WITH CROSS-BORDER ENVIRONMENTAL POLLUTION: LEGISLATIVE ASPECTS

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Abstract – Environmental torts and possibility of trans-border dispute settlement thereof has gained significant prominence in the recent years. Cases such as *Urgenda foundation v the State of the Netherlends, Milieudefensie et al. v. Royal Dutch Shell plc., ClientEarth v. Enea, Neubauer et al. v. Germany* demonstrate that environmental tort cases can be brought by stakeholders globally rather than relying on involvement of a relevant national responsible authority. EU climate policy of decreasing GHG emissions and the ambitious target of reaching climate neutrality by 2050 has resulted in a rapid development of environmental law. Thus, environmental regulation is becoming increasingly complex and possible breaches may cause serious legal consequences affecting everyone not just selected individuals or states. These developments could possibly lead to a necessity of a forum or rules where any natural person or an NGO could bring a claim against a state or multinational corporation which engages in illegal activities causing harm the environment on a global scale. Using litigation as a tool to empower society to stand against environmental wrongdoers may serve as a deterring factor to maintain order when it comes to environmental regulation. While such reasoning may seem farfetched and extreme, nevertheless it still raises a question of current regulation on determination of jurisdiction and the applicable law and whether it would be possible to benefit from developing these rules. By engaging in a systematic literature analysis identifying the relevant terms, the research shall explore the basic principles of private international law in relation to assigning jurisdiction and determining applicable law in claims concerning environmental torts. The research shall develop a methodology with the aim of covering and identifying a wider range of problems related to the determination of jurisdiction and application of law in cross-border environmental tort claims. Some of the main issues concern the determination of defendants in cases involving multinational corporations, multi-claimant cases, and the compensation of indirect damages. An exploration of material aspects in the developments of the current EU regulation and guidelines shall be analysed in conjunction with the aforementioned notion. The result of the study not only will reflect the specifics of the application of the Brussels Ibis Regulation and Rome II regulation in cross-border environmental torts, but also how the EU environmental regulation could potentially promote corporate responsibility and environmental protection, thus developing research on interaction between private international law and environmental law.

Keywords – Applicable law; cross-border pollution; environmental tort; jurisdiction; SEG emissions

07

ENVIRONMENT, HEALTH, POLLUTION PREVENTION

https://doi.org/10.7250/CONECT.2024.068

DESIGN OF A FERTILIZING ROBOT APPLICATION WITH REGARD TO ENERGY CONSUMPTION

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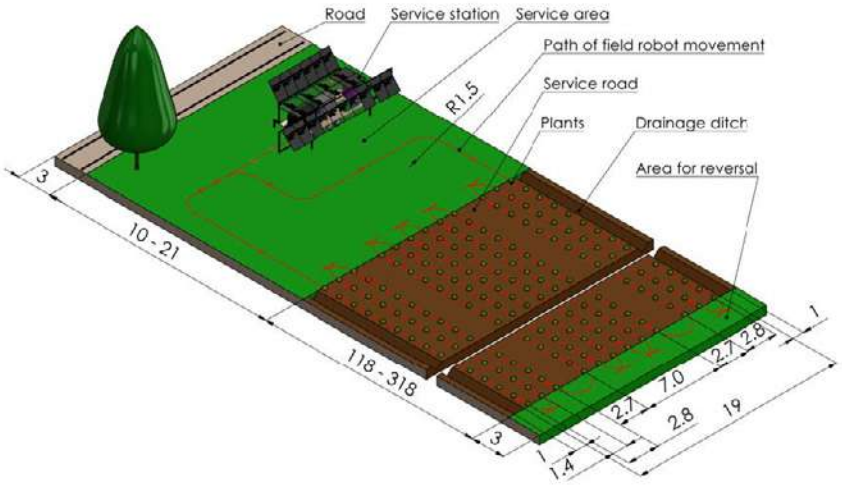
Abstract – Electrically driven agricultural robots experience faster battery depletion than vehicles moving on asphalt because higher rolling and traction resistance require more energy. The problem arises in areas without access to the electrical grid, where charging electrically driven agricultural robots is not possible, resulting in interruptions to the robot's continuous operation. A combined energy production station powered by biogas, hydrogen, and solar energy with the prototype of autonomous fertilizing robot for blueberry plantations to perform plant-based precision fertilization on depleted milled peat fields was created by the agrorobotics working group of the Estonian University of Life Sciences. The station includes unique components such as an automatic battery exchange system and an electric generator with a membrane motor. These, together with a solar energy and electric generator control system, as well as a battery charger, are mounted on a mobile platform. The objective of this article was to determine the energy requirements of an autonomous fertilizing robot during movement in the field and for carrying out technological operations. For this purpose, the mechanical power and energy required for the operation of the robot fertilizer spreader were first determined. Based on this, an accumulator with suitable power and capacity for the operation of the robot fertilizer spreader was selected. The travel distance of the robot on a single charge of the chosen accumulator was determined, as well as the traction power efficiency and specific power.

Keywords – Argicultural robot; biogas, hydrogen and solar energy; energy consumption; movable power station



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ACKNOWLEDGEMENT

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OPTIMIZING THE BATTERY MANAGEMENT ALGORITHM OF THE AGRICULTURAL ROBOT BASED ON THE WORKLOAD

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Abstract – This article focuses on optimizing the battery management algorithm to minimize the amount of energy remaining in the battery at the end of the workload. The increasing use of renewable energy to operate agricultural robots increases the autonomy of the robot's energy supply. The volatility of renewable energy in turn increases the need for a smart battery management system. In the case of non-optimized battery management, up to 25 % of the energy in the battery may remain unused, depending on the workload. A battery management algorithm was developed, which allows reducing the amount of residual energy remaining in the battery depending on the workload and increasing the time utilization factor of the agricultural robot. The concept was proven with computer models that use data of the energy consumption of the farming robot and the limitations of the workload due to the geometry of the cultivated fields.

Keywords – Agrorobotics; berry plantation; energy management; precision farming; smart farming

ACKNOWLEDGEMENT

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ENVIRONMENTAL PERFORMANCE OF A POLYAMIDE-BASED THERMOPLASTIC COMPOUND WITH BROMINATED FLAME RETARDANTS

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Abstract – Thermoplastic compounds are present in various industrial, domestic and consumer applications thanks to their strength, lightness, flexibility, and processing properties. However, thermoplastics are often derived from polymers formed from nonrenewable sources, such as petroleum. In addition, the production processes have a high consumption of energy. For this reason, assessing the environmental impacts caused by the production process is of primary importance. This research evaluates the environmental performance of a polyamide-based thermoplastic compound with brominated flame retardants. The objective is to understand which phase of the production process has the most significant impacts. The assessment of environmental impacts was carried out through the Life Cycle Assessment methodology using *SimaPro v9.5*, *Ecoinvent v3.9* database and *ReCiPe 2016 v1.07* impacts assessment method. The primary data were generated and collected in a factory in northern Italy, and the Functional Unit considered is 1 kg of final product. The results show that the upstream phase accounts for more than 90 % of the environmental profile, especially in human noncarcinogenic toxicity, with more than 56 % of the total impacts and fine particulate matter formation with 18 % shares. At the climate change level, the product delivers a total impact of 6.17 kg CO_2 eq per kg of the final product. This study indicates that most of the impacts are caused by the production of raw materials. For this reason, it is necessary to introduce more sustainable and environmentally friendly raw materials.

Keywords – Appropriate technology; circular economy; climate change; ecodesign; Life Cycle Assessment; sustainable processes; thermoplastics

ACKNOWLEDGEMENT

This work has been supported by the collaborative partnership between LATI Industria Termoplastici S.p.A Research and Development Department (R&D) and the Department of Theoretical and Applied Sciences (DiSTA) at the University of Insubria. LATI is involved in co-financing PhD program of M.sc Alberto Pietro Damiano Baltrocchi at the University of Insubria.

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METHODS FOR MEASURING THE IMPACT OF SUSTAINABLE TOURISM DEVELOPMENT ON CLIMATE AND ENVIRONMENT

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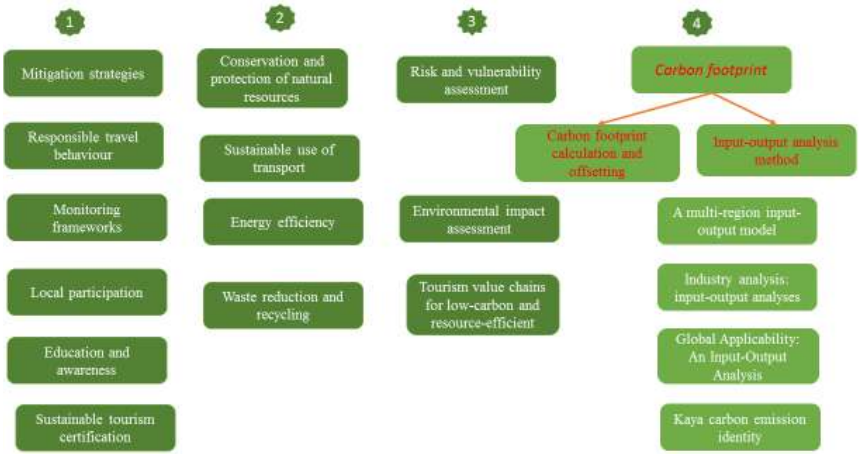
Abstract – Climate and environmental change is a growing topic in the post-Covid-19 period when tourism growth is recovering. Tourism is a significant polluter of the environment, and a rapid response to climate change is needed. Methods for assessing the climate and environmental impact of sustainable tourism development help to measure and communicate the environmental impact of tourism activities, but they are difficult to select and often lack indicators. The aim of the study was to choose methods for assessing the climate and environmental impact of sustainable tourism development in the context of Latvia. The study was based on the analysis of scientific literature, the grouping of methods for assessing the climate and environmental impact of sustainable tourism development according to their functional characteristics, i.e. 'preventive', 'protective', 'estimating' and 'carbon emission determining' methods. A multi-criteria decision-making method was used for the selection of evaluation methods – analytical hierarchy process with empirical analysis (AHA) of the obtained weights. By summarising the environmental and climate indicators available for a specific region of Latvia regarding the impact of tourism and experts evaluating the obtained results, the most suitable method for evaluating the impact of tourism development on the climate and environment is the Tourism value chain for low carbon content and efficient use of resources. However, the authors' recommendation for researchers is as follows: 1) when evaluating the impact of tourism development on the climate and environment, the choice of method ought to be based on evaluation indicators available for a specific study; 2) in research combinations of sets of 'evaluative' and 'carbon emission determining' methods should be used.

Keywords – Assessment methods; carbon footprint; CO_2 emissions; value chains



Methods of assessing the impact of sustainable tourism on the climate and environment. Note: 1 – 'preventive' methods; 2 – 'protective' methods; 3 – 'evaluative' methods 4 – 'carbon determining' methods.

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VULNERABILITY OF THE INFRASTRUCTURE: RISK MANAGEMENT AND IMPLEMENTATION OF THE INFORMATION SYSTEMS

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Abstract – This article focuses on a comprehensive view of the connection between infrastructure, risks, and Geographic Information System (GIS). In the context of the current era, where critical infrastructure faces various threats and risks, it is essential to explore new methods and technologies that enable better identification, assessment, and management of these challenges. The first part of the article analyses the current state of critical infrastructure and its connection to risks. Understanding how various threats, from natural disasters to cyber-attacks, affect infrastructure elements is crucial for effective protection and resilience. The second part examines the benefits and uses of Geographic Information Systems (GIS) in the context of risk assessment and management of critical infrastructure. GIS provides tools for collecting, analysing, and visualizing spatial data, improving the ability to identify key risk areas and their interconnections. The results of this paper demonstrate how effectively linking these elements can enhance the resilience of critical infrastructure to various hazards. Overall, this article provides an overview of current trends in connecting infrastructure, risks, and information systems, emphasizing the importance of this comprehensive approach to ensuring the security and sustainability of critical infrastructure.

Keywords – Critical infrastructure; informational system; resilience; risk management

ACKNOWLEDGEMENT

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JUSTIFICATION OF THE USE OF CONTAINER TECHNOLOGY IN DUMPING

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Abstract – The increase in the depth of the quarry is associated with an increase in the work of quarry transport in limited areas. A constant increase in the number of transport units is required, which increases the environmental burden on the environment. The rock mass extracted from the quarry is stored in external dumps, which occupy large areas and significantly worsen the ecology of the region. The operation of mining equipment on dumps with existing technologies causes a number of problems, the main of which is the movement of equipment near the prism of a possible rock collapse. It is proposed to use container technology for transporting the laying rocks in the dump, where the main element of the technology is a mobile lifting machine, which eliminates the need to build roads or railways on board and on the surface of the dump. Self-unloading of container equipment allows you pour the rock mass directly to the place of laying on the dump. Containers with rock are installed in front of the front of the dump, and the lifting machine is placed on a special platform of the dump. The rock mass is delivered from the faces by dump trucks of any load capacity and unloaded into the hopper of a plate feeder, which fills the containers as they are fed by a quarry lifting machine. The rock is laid in horizontal layers within the step of moving the lifting machine. The weighted average height of the rock rise is equal to half the height of the dump tier. With the new technology, the entire amount of work will be performed by one lifting machine. Increasing the height of the dump to 80 meters with a new method of dumping reduces the area occupied by dumps by 175 thousand m^2 per year. The use of container technology in the formation of the dump allows, when unloading rock from containers into the dump, to reduce energy consumption during the formation of the dump, and increase the economically advantageous height of the dump. This reduces the area occupied by dumps and reduces the harmful effects of mining on the environment. The article discusses the technology of dumping during the formation of dumps using bulldozers in the conditions of Northern Kazakhstan. Traditional technology involves the involvement of a complex of equipment consisting of 8 dump trucks and 1 bulldozer. According to the new technology, the same amount of work can be done by one lifting machine. Based on the calculations carried out, it was found that the intensity of dust emissions from internal sources decreases by 1,576 tons per year. A decrease in dust emissions is also observed with an increase in the height of the dump due to a decrease in area, while the difference was 75.57 tons per year. The total decrease from container technology is 1,651.57 tons per year.

Keywords – Conveyor; dump; efficiency; gripper; lifting machine; productivity; reloading unit

ACKNOWLEDGEMENT

This research is funded by the Science Committee of the Ministry of Science and Higher Education of the Republic of Kazakhstan (Grant No. AP19675410).

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STEPLESS TRANSMISSION OPTIMIZATION FOR GREEN MICROMOBILITY

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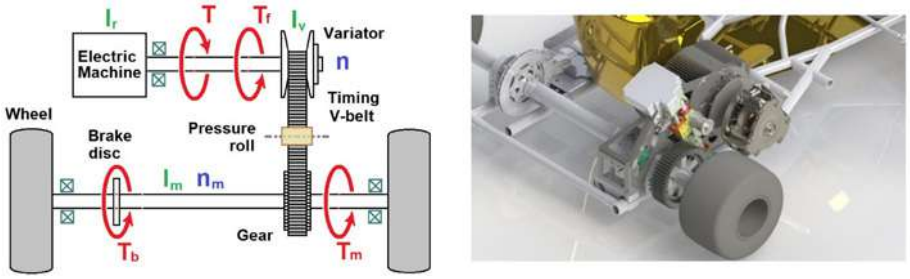
Abstract – Small, electrified vehicles are becoming possible for urban environmental mobility due to their environmental performance, including zero-emission driving. Vehicles of this type use electric motors as sources of mechanical energy. Today, two types of transmission are most used in electrical micromobility vehicles (skateboards, scooters, tricycles, quadricycles, mopeds, motorcycles, go-karts, etc.): chain transmission and belt transmission. This transmission types provides a constant gear ratio that can only compromise between the maximum speed and the starting torque values, thus reducing the usage efficiency of the engine. This reduces vehicle manufacturers' choice of less powerful drive and control elements, as well as balancing performance and efficiency at low and high speeds and on terrain. A novel design of a continuously variable transmission (CVT) for an electric go-kart is presented in this paper. The CVT consists of an inertial driving pulley mounted on an electric motor shaft, a timing V-belt, a gear wheel on the drive axle and 2 pressure rolls, which are moved by a servo motor for tensioning the V-belt. Gear ratio of a transmission can change seamlessly in the range of 1.5–2.2. The CVT has been tested under real conditions. The top speed of the electric go-kart with the given CVT and motor power 24.7 kW is 133 km/h; time to accelerate to the top speed is 25 s. Total efficiency of the transmission (motor shaft, CVT, drive axle and wheels) is 65–72 % now, but there exist a lot of possibilities to improve it in the future. The conditions under which the novel CVT has an advantage over belt and chain transmissions with constant gear ratios have been studied. The developed mathematical model, the method for determining its constants, the algorithm for numerical calculations and the optimization criterion makes it possible to determine the optimal gear ratio for a vehicle with various CVT (not only belt) at any point in time in different racing modes. The model has been proved experimentally during acceleration and deceleration tests of the go-kart; it describes precisely the motion of the go-kart within the speed measurement error. The developed solution is applicable in urban micromobility. An optimized and stable transmission system focused on energy efficiency, resource saving, using less powerful drive and zero-emission.

Keywords – Continuously variable transmission (CVT); electric vehicle; go-kart; green transport; micromobility



The drive of the go-kart. (A) Schematic of the CVT dynamic model; (B) 3D model of the CVT on the go-kart.

ACKNOWLEDGEMENT

This study is supported by the ERDF project "Continuously variable transmission for electric micromobility vehicles" KC-PI-2020/62 of Investment and Development Agency of Latvia (LIAA).

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ANALYZING VNO AIRPORT TRAFFIC DATA OF 2023: SPECIFIC AIRCRAFT NOISE MEASUREMENT AND MITIGATION RECOMMENDATIONS

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Abstract – The expansion of airport operations worldwide yields numerous advantages, yet it also brings about certain adverse consequences, notably noise pollution. In addressing noise pollution, airports deploy a range of noise control strategies, which can be broadly classified into four categories: passive noise mitigation methods, active noise mitigation strategies, regulatory measures, and technological innovations. The paper investigates the feasibility of Balanced Approach (BA) implementation at Vilnius International Airport (VNO according to IATA). In this study, an in depth analysis was conducted on the data pertaining to the frequency of movements, the distinct types, models and age of aircraft that utilized VNO facilities during the calendar year of 2023. Following the analysis conducted throughout 2023, a total of 38 699 aircraft movements were recorded, from which predominant aircraft types were identified: Boeing B737 (A1), Airbus A320 (A2), Airbus A220 (A3), Bombardier CRJ/Challenger (A4), Embraer (A5) and ATR 72-500 (A6). Average age of aircraft most frequently arriving and departing at VNO is 14.35 years. The sound measurements for A1, A3 and A6 were done with Bruel&Kjaer 2270 Investigator sound analyzer. Data then was post processed by BZ-5503 Measurement Partner Suite and measured data L_{eq}, L_{MAX}, different noise levels were compared. Measurements show that permitted noise levels are exceeded, especially by older age aircraft. Reducing air fleet age would be the most efficient noise mitigation measure according to BA.

Keywords – Aircraft noise; balanced approach; Vilnius City Airport; noise pollution

ACKNOWLEDGEMENT

Authors would like to express sincere gratitude towards the manager of Environmental Projects at Vilnius City International Airport Aldona Jokubauskienė for providing insights and expertise that greatly assisted the research.

08

WASTE. WASTE TO PRODUCT, VALUE ADDED PRODUCTS

https://doi.org/10.7250/CONECT.2024.076

INTEGRATION OF ACOUSTIC METAMATERIALS MADE OF PLASTIC TO IMPROVE BUILDING ACOUSTICS

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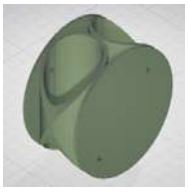
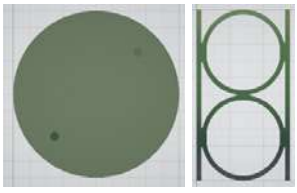
Abstract – According to the Waste Management Policy of the European Union, the recycling and reuse of various wastes is considered the most environmentally friendly and advanced waste disposal technology that has the least impact on the environment. By applying the principles of the Circular Economy, plastic waste will extend its life cycle and will be used as secondary materials to create metamaterial structures with improved sound absorption and insulation properties. Acoustic metamaterial resonators created from plastic were measured in an impedance tube according to standards ISO 10534-2 for their sound absorbing and ASTM E2611 for their insulating properties. Two types of plastic, PLA and recycled PET-G, were used in acoustic metamaterial 3D printing process. Sound absorption of both PLA and PET-G metamaterials was peaking at 1600 Hz with 0.93 and 0.89 sound absorption coefficient, respectively. For sound insulation, combined resonator systems were used to control symmetrical wall sound resonance. The aim of this study was to determine plastic potential for use in acoustic structures. The results showed that combined constructions with plastic metamaterials can be integrated into building structures and used as an alternative for improving building acoustics, reducing indoor noise and reverberation time.

Keywords – Sound absorption coefficient; sound transmission loss; Circular Economy; plastic waste; resonator

Axonometry	Front and side view	Sample code	Description
		O_L1.5_d1.5	O-shaped combined resonator with air gaps. Designed to act as a Helmholtz resonator. It has two holes (necks) on each side, so it can absorb longer waves (lower frequency). The neck length of this resonator is 1.5 mm and the diameter is 1.5 mm

Example of 3D printed acoustic metamaterial resonator.

ACKNOWLEDGEMENT

We would like to thank the VILNIUS TECH Institute of Environmental Protection for providing 3D printing materials and access to the 3D printer itself.

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INVESTIGATION ON PFAS SOURCES AND REMOVAL IN A MUNICIPAL WASTEWATER TREATMENT PLANT

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Abstract – PFAS (per- and poly-fluoroalkyl substances) is a complex family of manmade highly fluorinated aliphatic organic chemicals including thousands of chemical structures identified. PFASs were first synthesized in the 1940s and their physical and chemical properties such as oil and water repellency, temperature resistance, and friction reduction were then used in a wide range of products and industrial applications. Awareness about the possible health and environmental risks related to exposure to these substances has only risen in recent years and is resulting in the inclusion of such compounds in the Proposal for the recast of the Directive of the European Parliament and of the Council concerning urban wastewater treatment. Research was carried out at a municipal wastewater treatment plant (MWWTP) in Northern Italy to define the inflowing load of PFAS, the main load sources and the removal efficiency of the treatment processes. First, the contribution of the water supplied to the local population was excluded by means of specific chemical analyses. Then, the 100 industrial settlements served by the MWWTP were examined for the raw materials used, the final products and the productive cycle and 8 of them were selected as potential sources. A sampling campaign was carried out and the specific PFAS load was calculated. The total PFAS load entering the MWWTP was calculated from the analytical results and the flow. The percent contribution of each of the selected settlements to the total PFAS load was then calculated. 40 % derives from a textile dyeing industry and 32 % from a waste platform receiving also landfill leachates. 89 % of the total PFAS load comes from the sum of such contributions and two other activities: the processing of slaughterhouse wastes and the production of chemicals for agriculture. Specific investigations lead to attribute an important role also to fire drills and fire extinguishing, using Aqueous Film Forming Foams (AFFF) containing PFAS. Therefore, domestic contribution can be held as negligible. The removal in the WWTP was null and, in some cases, negative. As also reported in the literature, some precursors can be transformed in PFAS during the biological process and some sludge accumulated compounds can be released.

Keywords – AFFF; industrial contribution; PFAS load; PFAS removal

https://doi.org/10.7250/CONECT.2024.078

CHITOSAN/GRAPHENE OXIDE/SIO$_2$ NANOADSORBENTS FOR THE REMOVAL OF CR(VI) FROM WASTEWATERS

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Abstract – The swift industrialization and urbanisation have led to the discharge of significant amounts of hazardous heavy metals into water environments. Heavy metal pollution is currently one of the most significant environmental challenges being addressed, attracting researchers due to its biotoxicity and non-biodegradability even at minimal concentrations [1]. Chromium (Cr) is among the most prevalent heavy metal contaminants. Its oxidation state, Cr(VI), harms the environment yet has catastrophic consequences for human health [2]. It is removed by physical and chemical procedures such as ion exchange, chemical precipitation and electrochemical treatment. Yet, most of these procedures have downsides, such as the formation of hazardous sludge, causing disposal issues and the need for costly tools and monitoring systems [3] scanning electron microscopy and X-ray diffraction. Adsorption experiments were performed by varying pH, agitation speed, contact time, adsorbent dose and initial metal ion concentration. Freundlich, Langmuir and Temkin isotherms were used to analyze the equilibrium data obtained at different adsorption conditions. It was found that the adsorption isotherms were well fitted by the Freundlich equation and the adsorption process was found to follow pseudo-second-order rate kinetics. Adsorption results obtained show a maximum Cr(VI). Adsorption is regarded an appealing and favourable technology because of its ease of design, simplicity, and high efficiency. Carbon-based nanomaterials have been investigated as superior adsorbents in aqueous solutions for the separation of organic and inorganic contaminants. The current study recommends the usage of adsorbents based on graphene oxide (GO). GO is an oxygen-rich material that is produced during the oxidation of graphite. It features hydrophobic areas due to aromatic groups in the nanosheets' centres, along with a large number of hydrophilic functional groups such as hydroxy, aldehyde, epoxy, and carboxyl groups [4]. The latter allow GO to swell and perform electrostatic functions. Chitosan (Cs) is a great adsorbent since it is inexpensive, biocompatible, and causes no secondary pollution. Its molecular chains include -NH_2 and -OH groups, which can interact with heavy metal ions and give significant adsorption capacity [5] TiO2, and Fe3O4. The absorption equilibrium time of MCT was 40 min in absorbing vanadium (V). Silicon dioxide (SiO_2) nanoparticles with graphene oxide have better physical and chemical characteristics than graphene oxide-like surface area. Similar research has revealed that the presence of SiO_2 increases the adsorbent's adsorption capacity for Cr(VI) [6]. The effect of the pH value, contact time and initial chromium concentration was examined in order to determine the feasibility of Cs/GO@SiO_2. Its structure and the morphology were studied in detail by the application of BET, XRD, FTIR and SEM techniques. According to the results, the modification of Cs with GO@SiO_2 enhanced the percentage removal of chromium ions, especially, in acidic

conditions by using 0.5 g/L of the adsorbent. Experimental data of equilibrium were used to calculate adsorption isotherms. According to thermodynamics the spontaneous nature of their adsorption was confirmed. Overall, the results indicate that Cs/GO@SiO_2 can be effectively employed for removal of chromium from aqueous solutions.

Keywords – Adsorption; aqueous pollution; carbon-based materials; water treatment

ACKNOWLEDGEMENT

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ANALYSIS AND ASSESSMENT OF H_2S SORPTION CAPACITY OF THE SELECTED BIOFILTRATION MATERIALS

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Abstract – Hydrogen sulfide is known as one of the highly toxic chemical compounds found in the raw biogas that needs to be eliminated before implementation in any industrial sector. Biofilter (a typical bioreactor) is a tool used to separate sulfide/sulfate from hydrogen by biofiltration method, which is known as the green technology. Packing material is the main component inside a laboratory-scale biofilter to undertake the desulfurization process of H_2S. This study is dedicated to evaluating number of selected recyclable/waste organic, inorganic, and synthetic packing material's rate of impact on amplifying purification progress of hydrogen sulfide from biogas, known as biofilters 'removal efficiency (RE)'. Variable affecting factors, such as environmental and equipment conditions, consumed time (day), and inlet H_2S concentration will be controlled throughout the measurements for all chosen packing materials. In the end, the best performed environment-friendly biofiltration material in terms of sorption capacity of H_2S from the biogas will be announced.

Keywords – Biofilter; biogas; hydrogen sulfide (H2S), packing material; removal efficiency (RE)

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This work was conducted by Kamyab Mohammadi, a Ph.D. student at Vilnius Tech University. Measurements and format of the article was reviewed and acknowledged by Prof. Dr. Rasa Vaiskunaite and Alvydas Zagorskis from Vilnius Gediminas Technical University.

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SUSTAINABLE END-OF-LIFE TYRE MANAGEMENT: A COMPREHENSIVE ANALYSIS OF ENVIRONMENTAL IMPACTS AND CRUMB RUBBER INTEGRATION IN COMPOSITE CONCRETES

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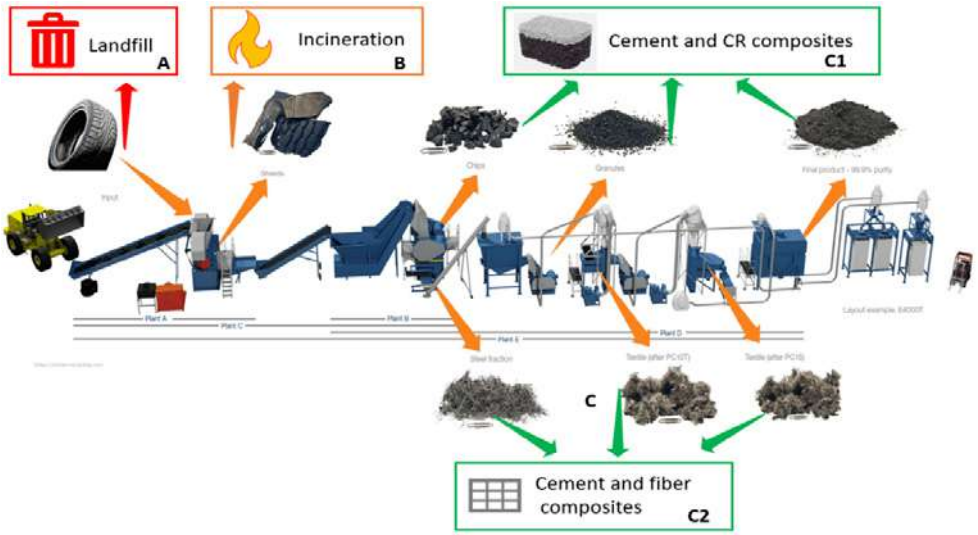
Abstract – The research explores pollution prevention strategies associated with end-of-life tyres (ELTs) through sustainable practices, focusing on repurposing ELTs into crumb rubber (CR) for use in composite concretes for civil engineering applications. Three disposal approaches are considered: recycling into crumb rubber for use in cement composites to enhance acoustic properties, incineration for cement production, and landfill disposal. The study aims to assess the environmental impact of each method, particularly in terms of carbon dioxide (CO_2) emissions during the recycling phase, utilizing the OpenLCA program for a comprehensive life cycle analysis. The primary objective is to provide insights into the sustainability of incorporating recycled rubber in concrete mixes as fine aggregate to improve concrete acoustic and shock absorbance properties. The research also gathers data on CO_2 emissions from ELT incineration for cement production and the environmental implications of ELT's landfill disposal. By comparing these three strategies, the study offers a holistic perspective on the environmental ramifications of ELT management. Notably, a recent study highlights the energy recovery and CO_2 emissions from ELT incineration, demonstrating the potential benefits of recycling. The research identifies a gap in existing studies, emphasizing the need to consider the entire life cycle, including the transportation and use stages.

Keywords – Acoustic properties; carbon dioxide emissions; environmental impact; life cycle analysis; pollution prevention; sustainable utilization



End-of-life tyre recycling process diagram with obtained products.

https://doi.org/10.7250/CONECT.2024.081

DEVELOPMENT OF GREEN ALKALI-ACTIVATED MORTAR BASED ON BIOMASS WOOD AS

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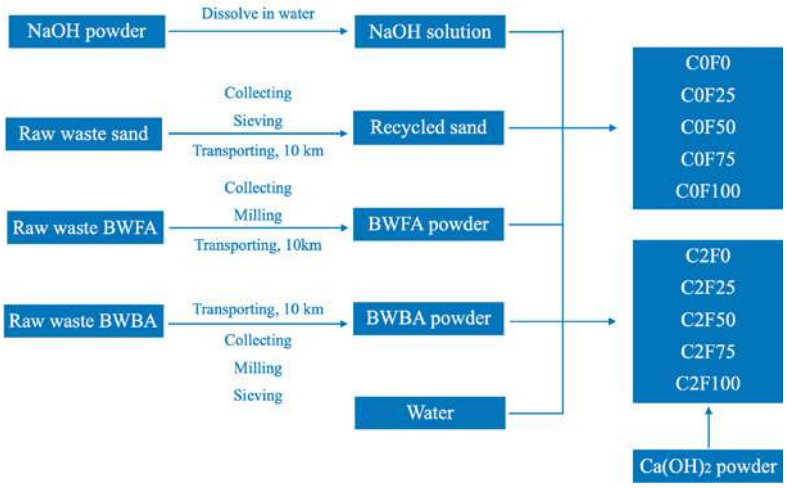
Abstract – Portland cement (PC) is the most commonly used binder material for producing concrete. Nonetheless, increasing concerns have been attached to its manufacture which is highly energyintensive and generates a large quantity of greenhouse gases. Developing cement-free alkali-activated materials as eco-binders is a sustainable replacement for PC, especially considering the possibility to utilize industrial by-products as precursors, which significantly reduces the environmental burden due to waste disposal. Many investigations have been reported successfully using coal fly ash, slag, and metakaolin as precursors. However, owing to the low reactivity, studies regarding biomass wood ashes (BWA) in the field of alkali-activated materials are still limited. To produce a green cementless alkali-activated mortar material, in this study, biomass fuel by-products – biomass wood bottom ash (BWBA) at 0 %, 25 %, 50 %, 75 %, and 100 % as well as biomass wood fly ash (BWFA) at 100 %, 75 %, 50 %, 25 % and 0 % were binarily used as precursors. Sodium hydroxide (NaOH) at 10 mol/L and calcium hydroxide ($Ca(OH)_2$) at 0 % and 20 % by binder mass were applied together as alkali activators. Recycled sand, substituting natural sand, was adopted as fine aggregate at an aggregate/binder ratio of 2 to reduce the consumption of non-renewable natural resources. The objective is to investigate the influence of various mix ratios of BWFA and BWBA on the produced alkali-activated mortar, and identify the effects of $Ca(OH)_2$. Compressive and flexural strength were tested to evaluate



Flowchart for lifecycle assessment of various mortar mixes.

the evolution of mechanical performance. A cradle-to-gate lifecycle assessment was conducted to analyse the environmental impacts. The results reveal that the alkali-activated mortar has less environmental impact compared to the traditional PC mortar. NaOH solution is the primary source of environmental influence and BWA only contributes to very limited impacts. When 50 % BWFA and 50 % BWBA are binarily used, the greatest mechanical properties are achieved. The usage of $Ca(OH)_2$ effectively improves the mechanical strength by a maximal 350 % (flexural strength) and 320 % (compressive strength), but meanwhile increases environmental burdens.

Keywords – Calcium hydroxide; compressive strength; flexural strength; lifecycle assessment; sodium hydroxide; recycled sand

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ANALYSIS OF INTRODUCING PLASTIC WASTE ENZYMATIC RECYCLING FOR SUSTAINABLE WASTE MANAGEMENT IN LATVIA

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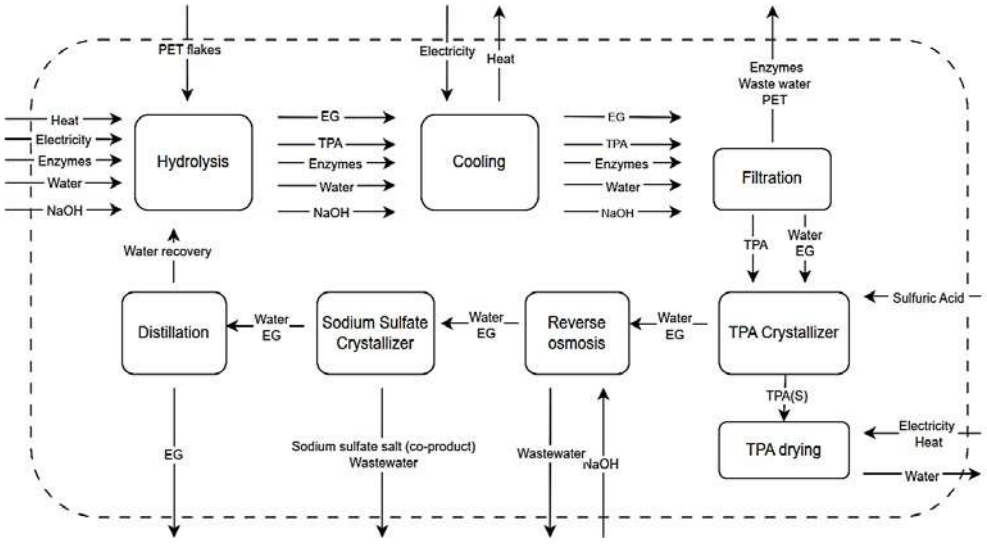
Abstract – Economic growth, urbanisation, and consumer consumption habits have contributed to the yearly increase in the municipal solid waste amount. A significant portion of household waste consists of plastic materials and packaging, which currently cannot be fully and endlessly recycled, does not decompose in nature, and degrades into micro- and nanoparticles entering the soil, air, aquatic environments, and organisms. According to an OECD report from 2022, the amount of plastic waste produced globally is expected to triple by 2060, with around half being landfilled and less than one-fifth being recycled. As waste volumes are going to increase, the need to ensure appropriate waste recycling technology is addressed in this study by introducing enzymatic plastic waste recycling in Latvia. Enzymatic recycling has an advantage over mechanical recycling technology because it can depolymerise plastics without degrading the quality of the material. The methodology applied in this study includes data analysis of the waste amount in Latvia, analysis of the existing plastic recycling plant operation, life cycle assessment of existing and proposed methods, and socio-economic impact evaluation. The proposed solution meets the objectives of promoting sustainable plastic waste recycling through the introduction of enzymatic recycling; therefore, it aligns with the European Union's targets to follow circular economy principles.

Keywords – Biological recycling; hydrolysis; life cycle assessment (LCA); municipal solid waste; plastic depolymerization; poly(ethylene terephthalate) (PET); terephthalic acid (TPA)



PET flake enzymatic recycling scheme.

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HOW DOES A DECISION-MAKING TOOL ENHANCE SPENT MUSHROOM SUBSTRATE VALORIZATION INTO POLYSACCHARIDES?

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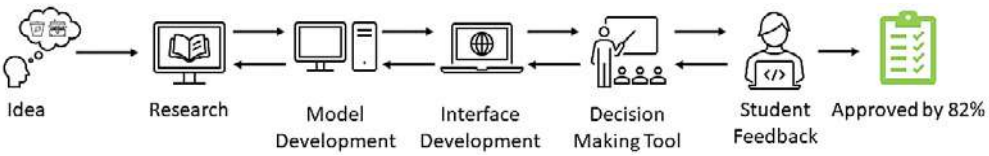
Abstract – In mushroom farming, one kilogram harvested results in about five kilograms of spent mushroom substrate (SMS), posing an environmental management challenge. As an in-tune work with the concepts of circular economy, cleaner production, and waste minimization, this study has developed a mathematical model that analyses the valorisation potential of SMS through polysaccharide production. The in-depth mathematical model is based on a system dynamics approach, which explains the interactive interplay amongst the production process, related costs, energy consumption, and caused emissions. The model has been developed in a generic way. Therefore, it can be re-adjusted flexibly for a different cleaner production process. A user-friendly interface has been developed. Users can easily manoeuvre around the variables within the model that offers instantaneous insight into the environmental and economic impacts of SMS valorisation. This interface was later integrated into an educational context to serve as an interactive decision-making tool for cleaner production modelling. The main purpose of the developed tool was to favour understanding of causalities between production chains, energy consumption, labour, emissions, and expenses. This tool has been tested on master's degree students in a cleaner production course. Survey results show that 82 % of students report the need to incorporate similar decision-making tools in their learning curriculum. In sum, the application of system dynamics to the valorisation of SMS does not only present an attractive solution for this environmental problem but also shows great potential in setting educational backgrounds for an interactive and close-to-life learning process. It is recommended to develop more interactive tools available for students.

Keywords – Bioeconomy; cleaner production; emissions; renewable energy; survey; system dynamics modeling



Research study framework for decision making tool development and approval.

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DEVELOPMENT OF SUSTAINABLE 3D PRINTABLE TERNARY COMPOSITE

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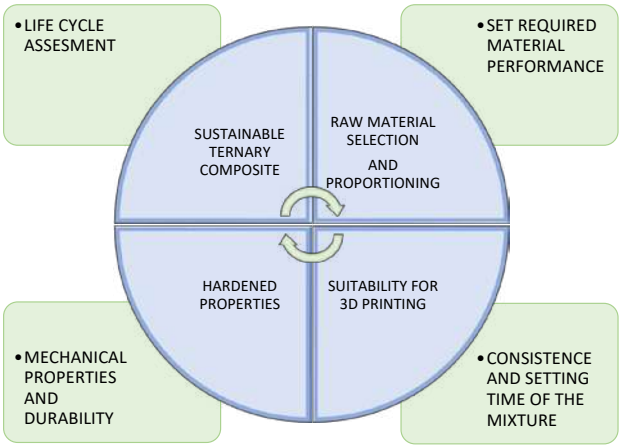
Abstract – 3D printing technology has the potential to reduce construction waste through its controlled manufacturing process and optimized material consumption, making it a promising sustainable construction approach with reduced environmental impact. However, current 3D printed structures often have a high carbon footprint due to the large amounts of fine-grained primary materials used in mortar composites. Most efforts to develop 3D printed structures are associated with concrete and Portland cement-based materials. This research presents an innovative approach for the reuse of gypsum to develop a material suitable for 3D printing, with the goal to industrialize the usage of waste gypsum in civil engineering. The objective of this study is to develop a sustainable gypsum-cement-pozzolanic (GCP) ternary binder composite, incorporating recycled industrial waste gypsum materials such as construction demolition waste gypsum (CDG), along with Portland cement and secondary pozzolanic materials. The GCP ternary composite combines the desired properties of gypsum, such as fast setting time, with those of Portland cement, which offers high final strength. The addition of a pozzolanic component is essential to ensure the chemical stability of this ternary system. As part of this study, ternary composites were designed and tested for their mechanical properties, durability, and suitability for 3D printing. Development and optimization of the ternary composite was carried out as a loop of procedures (see figure). Through these optimization procedures, a range of mixtures with necessary properties for 3D printing was found. To ensure sustainability and to assess the environmental impact of the mixtures, life cycle assessment (LCA) was performed. The LCA of GCP composites showed at least 1.5 times lower embodied energy and carbon dioxide emissions compared to Portland cement-based mortars. This is without considering avoided emissions from the end-of-life stage of gypsum waste, as well as higher technical properties that make GCP composites superior to regular cement composites. Considering these factors, GCP composites exhibit even lower emissions and are considered a viable alternative to Portland cement-based mortars.

Keywords – Additive manufacturing; Life Cycle Assessment; recycled gypsum; sustainability; ternary composite; waste materials



Optimization of the GCP ternary mixture.

ACKNOWLEDGEMENT

This research is funded by the FLPP (Fundamental and Applied Research Projects) program in Latvia under the research project lzp-2022/1-0585, “Development and Characterization of Sustainable Gypsum-Cement-Pozzolanic Ternary Compositions for 3D Printing”.

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SUSTAINABILITY OF BLENDED TEXTILE. LIFE CYCLE ANALYSIS

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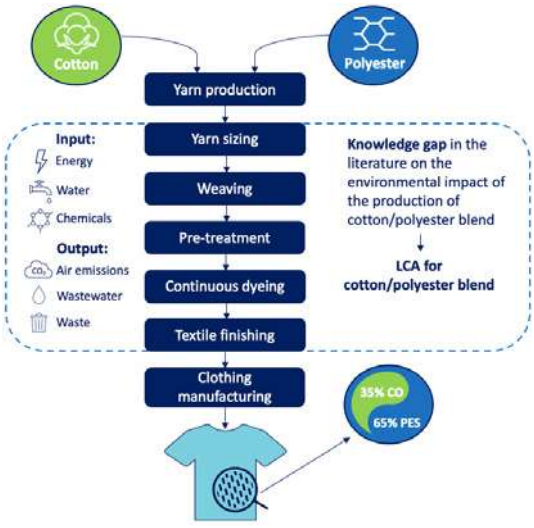
Abstract – Textile fibers are derived from natural and artificial fibers and, in some cases, are blended together to ensure optimum properties. Textiles made from cotton and polyester blends currently hold a significant market share as they are relatively inexpensive, offer excellent performance, and have complementary properties. This textile blend is commonly used in everyday apparel. However, the production and consumption of textiles contribute significantly to environmental degradation and greenhouse gas emissions, but the scale of the impact is uncertain and under debate. This is also the case in studies of cotton and polyester blends, as a detailed life cycle inventory of the production of this material is absent in the scientific literature, thus affecting its environmental impact assessment. Therefore, the aim of this study is to fill the knowledge gap by assessing the environmental impacts of cotton and polyester blend production and to establish a comprehensive life cycle inventory for the material. The findings of the study can contribute to a more comprehensive evaluation of the life cycle of cotton and polyester blend textile products and work as a baseline scenario for the environmental impact assessment of various innovative textile recycling technologies. This is especially important as recycling of cotton and polyester blends is currently a major challenge. Additionally, these results can be of practical significance to assist businesses and policy makers in making environmentally informed choices.

Keywords – Cotton; environmental impact; fabric; Life Cycle Inventory (LCI); mixed fiber; polyester



Environmental impact assessment of the production of cotton and polyester blends.

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END-OF-LIFE MANAGEMENT OF PHOTOVOLTAIC PANELS: A MODEL FOR FORECASTING AND ECONOMIC EVALUATION

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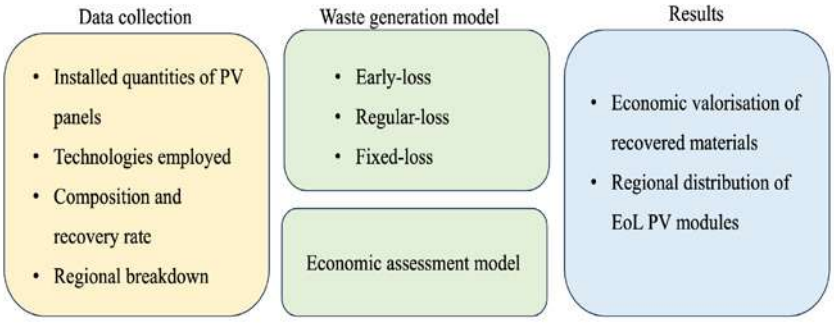
Abstract – The global surge in photovoltaic (PV) panel deployment since the 2000s has contributed to advancing the renewable energy sector. However, this proliferation raises concerns about the increasing number of PV modules that will end their operational life in the coming years, necessitating effective planning for their decommissioning and recovery. This paper addresses this imminent challenge by presenting a predictive model to estimate the volume of decommissioned modules from existing installations. To take into account the variability associated with the operational life duration of PV panels, three distinct scenarios were considered: early loss, regular loss (both modelled through the Weibull function) and fixed loss. Furthermore, the article introduces a methodology for the economic valorisation of materials recovered from decommissioned PV modules, according to the different technologies employed. This approach encourages sustainable practices by assigning an economic value to recovered materials, promoting a circular economy in the renewable energy sector. The economic valuation methodology adds practicality to dismantling, emphasising responsible waste management's potential economic benefits. In order to illustrate the applicability of the model, the study focuses on the Italian case, providing a detailed regional breakdown. The regional analysis not only improves the accuracy of the predictive model but also offers insights into localised PV module disposal patterns. By adapting the model to the individual Italian regions, the article serves as a concrete and valuable resource during the programming and planning phases, facilitating the implementation of a strategy to efficiently recover PV modules and consequently minimising the environmental impact associated with decommissioning activities.

Keywords – Circular economy; economic assessment; EoL PV modules; recovery; sustainability



Research phases.

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SOUND ABSORPTION EVALUATION AND ANALYSIS OF DIFFERENT HEMP FIBER TYPES

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Abstract – In recent years, the global conversation surrounding sustainable practices and environmentally friendly alternatives has gained significant momentum. Hemp fiber presents a compelling alternative to conventional sound-absorbing materials, such as fiberglass, foam, and mineral wool. Hemp fiber offers a plethora of positive environmental aspects from mitigating deforestation to reducing carbon emissions. In this study, six different types of hemp fiber samples were tested: bleached hemp fiber (BHF), cottonized hemp fiber (CHF), boiled cottonized hemp fiber (BCHF), decorticated well stripped hemp fiber (DWSHF), decorticated short, not combed hemp fiber (DSNCHF) and decorticated short hemp fiber with 40 % hurds (DSHFH). The sound absorption was measured using the impedance tube, transfer function method in accordance with ISO 10534-2 standard. The hemp fiber samples were changed in thickness of 20 mm, 40 mm, 60 mm and density from 50 kg/m^3 to 250 kg/m^3 in steps of 50 kg/m^3. It has been found out that all of hemp fiber types absorbs sounds of medium (600–2000 Hz) and high (2500–5000 Hz) frequencies very well. The sound absorption coefficient reaches up to 0.99 at medium and high frequencies. Absorption peaks occur at frequencies of 1000 Hz, 1250 Hz, 1600 Hz, 2500 Hz, 3150 Hz, 4000 Hz, 5000 Hz, depending on the measured fiber thickness, density, and type of measured fiber. It has been determined that in all cases, increasing the thickness of the hemp fiber sample increases sound absorption at lower frequencies. Sound absorption at lower frequencies also generally increases when using denser fibers, but this also depends on the type of hemp fiber being studied. Peaks in the sound absorption coefficient of 0.96–0.99 were mostly achieved when testing fibers with density of 50 kg/m^3, 100 kg/m^3, and 150 kg/m^3.

Keywords – Hemp; natural fibers; sound absorption coefficient; sound absorbing materials

Types of hemp fibers studied (cottonized h.f., bleached h.f., decorticated h.f. (well stripped), boiled cottonized h.f., decorticated h.f. (short, not combed), f – decorticated short h.f. with 40 % hurds).

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WET EXTRACTION OF BY-PRODUCT SAMPLES AND FRACTIONATION OF VALUABLE COMPOUNDS USING SUPERCRITICAL CO_2 EXTRACTION: AN INNOVATIVE APPROACH FOR SUSTAINABLE RESOURCE UTILIZATION

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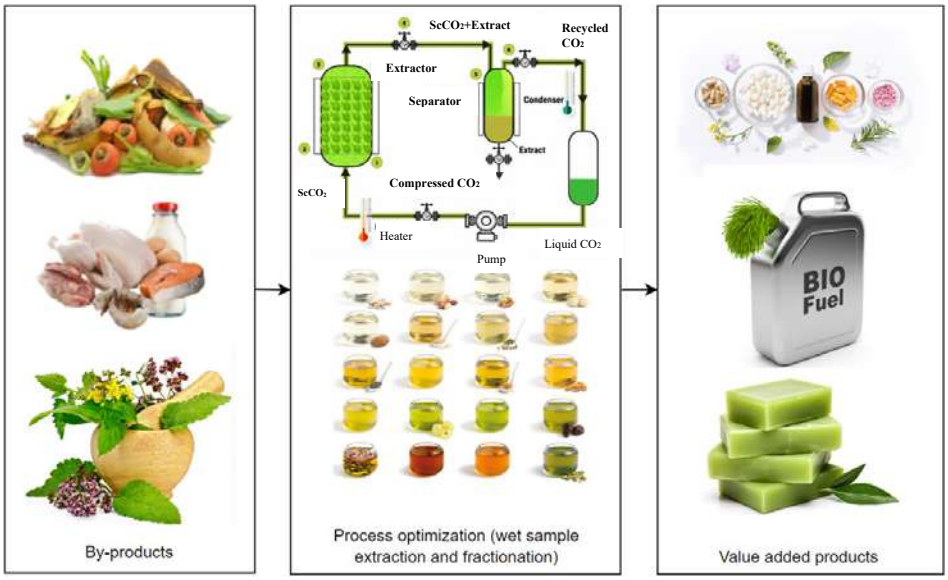
Abstract – This research explores an innovative method for extracting and fractionating valuable compounds from byproduct samples through the utilization of supercritical carbon dioxide (SC-CO_2) extraction. By-products generated from various industrial processes often contain untapped reservoirs of valuable compounds, necessitating environmentally sustainable and economically viable extraction techniques. SC-CO_2 extraction, known for its unique properties such as low toxicity, non-flammability, and tunable solubility, presents a promising avenue for efficient and selective extraction of target compounds. The study focuses on wet extraction, emphasizing the extraction of valuable compounds from by-products in their natural, moisture-laden state. This approach not only enhances the sustainability of the extraction process by minimizing pre-treatment steps but also broadens the scope of potential target compounds. The study further explores the critical parameters of SC-CO_2 extraction, including pressure, temperature, and flow rate, to optimize the extraction efficiency and selectivity for different classes of compounds.

Keywords – By-products; fractionation; supercritical CO_2 extraction



Optimizing supercritical CO_2 extraction.

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OPTIMISATION OF THE PRODUCTION OF BIO-BASED BASIC CHEMICALS FROM BIOGENIC SECONDARY WASTE THROUGH DISPERSION

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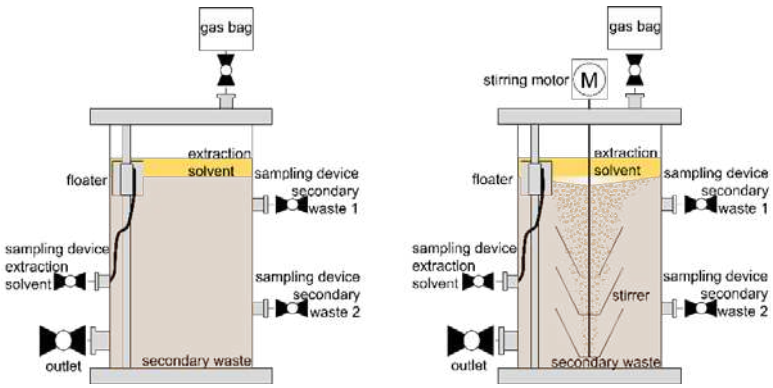
Abstract – Biogenic waste from waste treatment plants, also known as secondary waste, can be used to produce bio-based carboxylic acids. Conventionally, these are produced by chemical synthesis of petroleum-based raw materials or synthesis of natural oils (e.g. coconut or palm kernel oil). Using organic residues and waste materials in a cascade to produce bio-based products can contribute to the circular bioeconomy. In the biological treatment process for production of bio-based carboxylic acids, microorganisms that are already present in the secondary waste use ethanol to convert short-chain carboxylic acids (with one to three carbon atoms) into medium-chain carboxylic acids (with four to ten carbon atoms). During the treatment process, medium-chain carboxylic acids are separated from the secondary waste by using in-situ extraction (liquid-liquid extraction). In previous studies, bioreactors without a dispersing function were used on a laboratory scale. In order to optimise the production and extraction of the formed medium-chain carboxylic acids, the bioreactors should be upgraded with a device for dispersing the extraction solvent in the secondary waste. Dispersing can increase the surface area between the extraction solvent and the secondary waste, and therefore, also the ability to extract the medium-chain carboxylic acids. To evaluate the effects of dispersing on the production of bio-based carboxylic acids, the production and extraction rates of static bioreactors without dispersing are compared with those of dynamic bioreactors with dispersing on a laboratory scale. Leachate from a composting plant was used as secondary waste. According to the results of the current study, it can be confirmed that dispersion has a positive effect on the biological treatment process. In addition to the increased degradation of the nutrient ethanol, the production of medium-chain carboxylic acids in the secondary waste as well as the extracted medium-chain carboxylic acids could be increased by dispersing.

Keywords – Bioeconomy; carboxylic acids; circular economy; composting plant; fermentative extraction; leachate; liquid-liquid extraction



Technical design of static bioreactor (left) and dynamic bioreactor (right).

ACKNOWLEDGEMENT

The study was supported by the Research Centre for Sustainable Processes and Technologies of the Darmstadt University of Applied Sciences, a member of EUt+ as well as the research project "Combination and extension of treatment processes for biological waste and residues by biorefinery units to produce high-quality bio-based products", funded by the German Federal Ministry of Education and Research (BMBF, FZK 031B0661B).

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BIODEGRADABLE WASTE MANAGEMENT IN GEORGIA: PROBLEMS OF THE COMPOSTING SYSTEM INTRODUCTION

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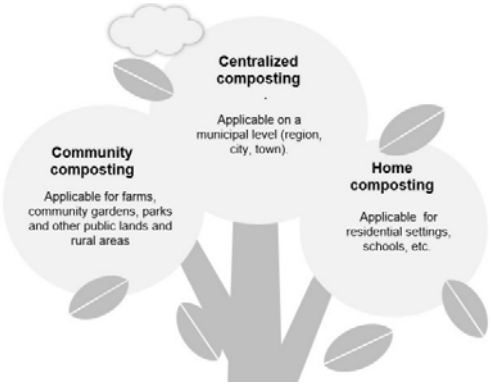
Abstract – Biodegradable waste management, in particular the introduction and implementation of composting systems are among the major problems for Georgia. An increase in the volume of municipal waste has been recorded in the country; therefore, the volume of generated biodegradable waste is also increasing. In accordance with the National Waste Management Strategy 2016–2030 of Georgia, the municipal waste generated in 2021 amounted to 1 104.952 tonnes. It is worth noting that the largest part of municipal waste is organic waste – 54.7 %, while plastic waste is 13.8 %, paper and cardboard – 10.6 %, textiles – 4.1 %, and other waste. According to various studies, by 2030, waste generation is expected to increase from 0.6 % to 1.2 % annually, which should be the cause of significant challenges for national and local authorities, especially local municipalities, whose duties include municipal waste collection and transportation as well as the implementation of separate waste collection systems. Biodegradable waste management, including various composting systems, is of particular importance. The study shows that composting, as one of the best approaches for recycling biodegradable waste, is still not properly developed in Georgia. It is possible to name only a few successful experiences. Noteworthy among them is the Kutaisi Composting Center, which was established within the framework of the EU JOP "Black Sea Basin" in Kutaisi, Georgia. The Composting Center is designed for windrow composting of green waste (tree branches, leaves, grass). Its productivity is 2000 tonnes of compost annually. The Composting Center is one of the first in Georgia. It can bring very tangible benefits. In particular, the amount of municipal waste going to landfill sites was reduced by approximately 10 %; the expenditures of the municipalities connected to the maintenance of green facilities (received compost is used) have been reduced. Among biodegradable waste composting approaches, it is recommended to use such systems as: i) centralized composting, ii) community composting and iii) home (individual) composting. A centralized composting method can be used in municipalities where a large amount of biodegradable



Composting approaches recommended for introduction in Georgia.

waste is generated. It is especially favourable in regions, where the agricultural sector is developed, and large amounts of green waste are generated. The Kutaisi Composting Center is a good example of the centralized composting system. As experience shows, such large-scale composting is particularly effective for green waste composting. It is promising for Georgia to introduce community composting approaches that offer an optimal scheme for communities to get the maximum benefits of their potential. Composting is an approach used in the field of biodegradable waste management that has the greatest potential in Georgia and can make a significant contribution to both economic development and the protection of the social and natural environment.

Keywords – Biodegradable waste; centralized composting; community composting; individual composting; green waste; recycling; separation; waste management

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STEARATE FROM STEEL WIRE DRAWING PROCESSES AS A RESOURCE

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Abstract – Wire drawing processes are well established: steel wires are made by pulling wire rods through conically converging dies with gradually decreasing sections. As a result of the pulling force on the wire rods, the wire diameter is gradually reduced. Dry lubricants are needed for lubrication, as they form a thin layer between the wire and the die surface to prevent direct contact and reduce friction. Calcium and sodium stearate soap powders are mainly used as dry lubricants. With prolonged use, the concentration of metals like zinc, iron, calcium, and magnesium increases leading to contamination. Also, the burnt component in the soap powder increases, resulting in improper lubrication. Thus, fresh lubricant replaces the used dry lubricants that are collected and discarded. However, very few data are reported in literature about characterization and recycling of the used lubricant powder.

The aim of STAR (Stearato dai processi di Trafilatura del filo di Acciaio come Risorsa) project, funded by the Italian Ministry of the Environment, is the valorisation of stearate waste from wire drawing process in the production of new materials (material recovery) or as an energy source (energy recovery). To achieve this goal, a characterisation of stearate waste was performed. Samples of stearate waste were provided by wire drawing industries. The analyses showed that the humidity content was always low (0.1–5 %), while the volatile solids content varied from 2 % to 70 %, covering a very wide range and thus indicating a variable organic matter content. The results of the determinations of higher heating value and chemical oxygen demand correlated well with those of volatile solids, with an average of 26 MJ/kg and 500 mg O_2/g, respectively. Measurements also confirmed that the used lubricants have a basic pH (> 11). Anaerobic digestion can surely have an important role in valorisation, as it allows to recover energy and to produce a stabilized digestate for which a further use can be studied, according to its properties. Despite the potential limits in biogas production observed for fatty acids, preliminary tests determined a biomethane production in the range 500–900 L/kgVS, much higher than the production from animal waste (around 400 L/kgVS). The toxicity of the digestate was assessed by Microtox® assay and was negligible. This finding supports the hypothesis that recalcitrant compounds, which do not undergo degradation in anaerobic conditions, are not toxic.

Keywords – BMP (biomethane production); characterization; material recovery; stearate waste

ACKNOWLEDGEMENT

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FACTORS AFFECTING WASTE RECYCLING HABITS IN LATVIA – RESULTS FROM AN ONLINE SURVEY

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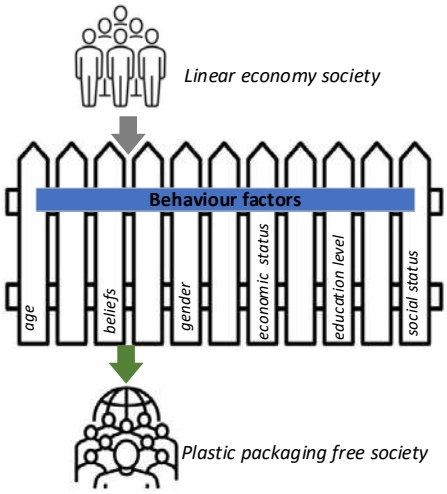
Abstract – While waste sorting is compulsory within the European Union, not all households in Latvia have the access to the waste sorting bins nor wish to recycle their household waste even if the bins are available. Despite the fact that several surveys have been conducted concluding that the recycling rates in Latvia are improving with every year, it is still not clear what factors determine waste sorting and sustainable consumption habits in Latvia. Therefore, the goal of this study was to identify factors that could be seen as predeterminants for waste sorting and sustainable consumption habits among the citizens of Latvia. Prior to the survey, an extensive literature search was made to identify and understand what are the most prominent sociodemographic and other factors that could affect waste sorting, plastic consumption, or sustainable behaviour habits. Literature findings revealed a heterogeneity of factors that could not be fully attributed nor classified based on the region of the country, some cultural aspects, the customs, or specific socio-demographic factors, indicating that the sustainable behaviour was mostly country specific, and, therefore, could not be generalised to all the countries. Based on these findings an online survey was made. It was conducted for a one-month period between the end of January and the end of February 2024. The data from different age groups of citizens of Latvia were collected. The results of the survey should shed a light on the factors that could be seen as determinants for waste sorting and sustainable consumption habits (or lack of them) among the inhabitants of Latvia. These results could help to develop better communication strategies based on the survey results to help to improve recycling indicators in Latvia.

Keywords – Barriers; behaviour; socio-demographic factors; sustainable consumption



Behaviour factors against plastic packaging free society.

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UNDERSTANDING MUNICIPAL GREEN INITIATIVES AND CITIZEN HABITS IN FOUR BALTIC SEA REGION COUNTRIES: SURVEY RESULTS

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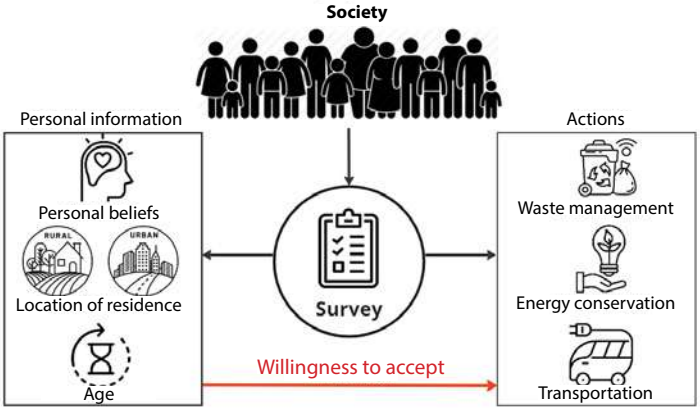
Abstract – The need to reach climate neutrality is addressed in this study by highlighting activities including boosting renewable energy sources, improving energy efficiency, and putting laws and incentives in place for the adoption of low-emission technology. Importantly, it is recognized that there is another important key factor in determining the success of sustainability projects, which is an individual's willingness to change their behavior and accept new guidelines. This cross-cultural research examines the everyday routines of people in Sweden, Estonia, Latvia, and Poland. It also looks at the way these residents evaluate their municipalities. The research investigates the connections between citizens' behaviors regarding waste management, energy conservation, and transportation by considering the inhabitants' age, location of residence, and personal views. This study aims to collect the necessary data for creating focused, culturally appropriate sustainability projects. The study promotes international cooperation on environmental issues, supports sustainable practices adapted to various cultural settings, and gives policymakers useful information. Using a survey, this study takes a thorough approach to comprehending and resolving sustainability issues. The findings demonstrate that interventions need to be tailored to specific characteristics and cultural contexts to effectively encourage durable behaviors. All things considered, this study adds to the current conversation on sustainability by providing information and suggestions for encouraging environmentally friendly behavior in a variety of cultural contexts.

Keywords – CO_2 emissions; local policies; renewable energy; sustainable behaviors; sustainable transportation; waste management



Research methodology.

https://doi.org/10.7250/CONECT.2024.094

HOW TO NOT WASTE GLASS WASTE

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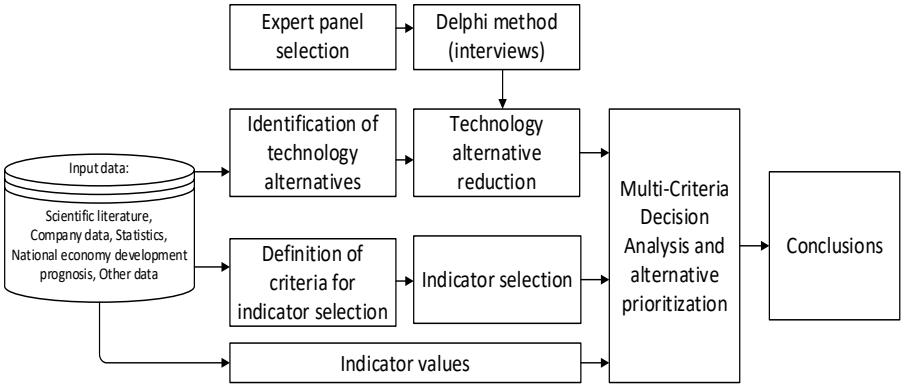
Abstract – As a highly versatile material, glass is used for numerous significant applications in our lives: from building structures to household products, to optical instruments, etc. Even more impressive than its versatility is the theoretically endless recycling opportunities of glass. While closed loop recycling is preferred due to raw materials savings and lower CO_2 emissions, it is oftentimes hindered by the quality and impurities in the collected glass waste. The technical limitations to recycling may be application specific, for example, if the post-consumer glass collection systems cannot guarantee the required high quality and thus closedloop recycling is disregarded. Moreover, there are economic and environmental limitations to glass recycling. The aim of the paper is to set a base for comparative analysis of scenarios for the potential development of glass recycling model in Latvia. The methodology algorithm of the proposed study consists of three main parts, namely, composition of database required for the analysis, building of the analysis framework, i.e., selection of technology alternatives and assessment criteria (indicators), and application on MCDA by TOPSIS method. A literature review on novel glass waste valorization techniques is performed and the summary conclusions will be used for further research development.

Keywords – Glass waste; recycling; technology alternatives; valorization



Methodology algorithm of the study.

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RECYCLING POSSIBILITIES OF WOOD-CEMENT PARTICLE BOARD MANUFACTURING WASTE

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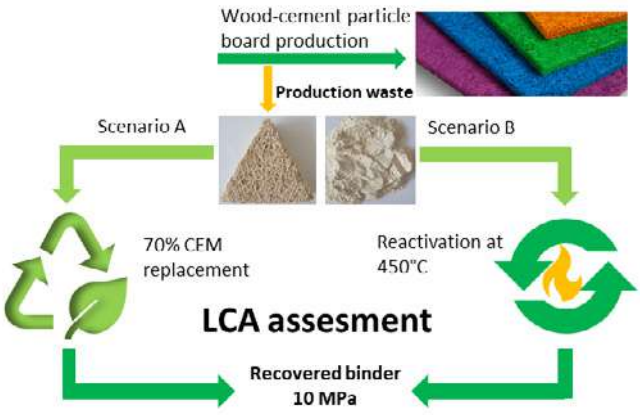
Abstract – Wood-cement particle boards are gaining popularity within construction materials as they combine natural fiber architectural value with Portland cement durability. The production of the material is associated with processing the produced fiberboards, which includes cutting, grinding, and polishing. The remaining wood-cement dust residues are classified as production waste, which is now deposited in the dump and gives extra expenditure for the enterprise. The utilization of wood-cement dust would also benefit the circular economy and reduce the environmental impact of the production process. Two scenarios are analysed in this research, and the life cycle assessment (LCA) tool with *SimaPro* software is compared. The first scenario is associated with the partial replacement of Portland cement with wood-cement dust powder. The second scenario offers re-activation of the wood-cement dust at 450 °C to obtain binder properties. Both materials' mechanical strength is comparable, reaching 10 MPa after 28 d curing. To maintain target strength, 70 % of Portland cement can be replaced. To produce 1 t of binder by heating at 450 °C, 1.2 t of wood-cement dust is needed as natural moisture evaporates, and wood dust particles go through pyrolysis, giving extra heat and CO_2 emissions as well. LCA results indicate that the 70 % replacement of Portland cement reduces CO_2 emissions from 597 kg of CO_2/ton of CEM II/A-LL 42.5 to 179 kg of CO_2/ton, while the second scenario is associated with high energy consumption during burning of the binder and increased CO_2 value due to fossil fuel consumption and CO_2 release from burning organic compounds in the material.

Keywords – Binder; circular economy; composite; life cycle assessment



LCA scenarios of wood-cement particle board production waste recovery.

ACKNOWLEDGEMENT

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ADVANCING SUSTAINABLE ACOUSTIC SOLUTION: EXPLORING THE SOUND ABSORPTION CHARACTERISTICS OF BIODEGRADABLE AGRICULTURAL WASTES, COCONUT FIBER, GROUNDNUT SHELL, AND SUGARCANE FIBER

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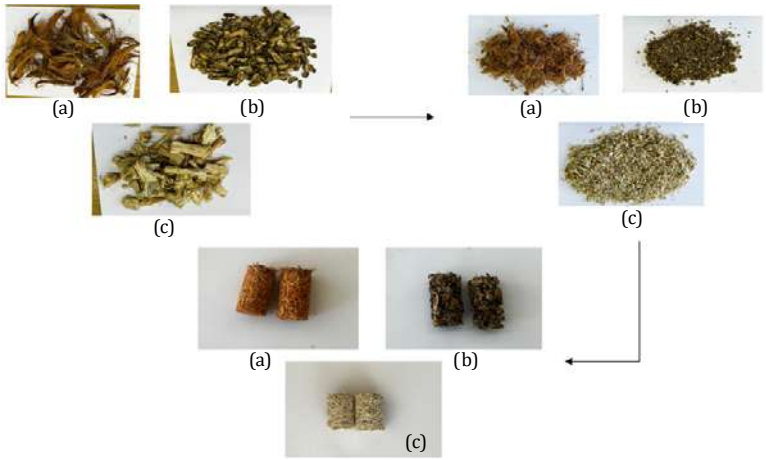
Abstract – Noise pollution is one of the most pressing global health issues affecting the well-being of inhabitants in densely populated cities. It affects urban areas, significantly impacting the quality of life for residents. The effects extend beyond mere annoyance, as noise has negative impact on health, emotions, and human behaviour. As noise pollution persists, researchers are exploring innovative solutions, with a particular focus on the potential use of natural fiber sound insulation materials. The conventional synthetic materials used in the sound insulation industry have a set of environmental and health risks. Based on these risks, attention has turned to the utilisation of the properties of biodegradable natural fibers, coconut fiber, groundnut shell, and sugarcane fiber as potential substitutes for synthetic materials. These materials do not only demonstrate sound absorption capabilities but are also ecofriendly and pose low risk to the environment and human health. The research examines the sound absorption characteristics of these natural biodegradable agricultural waste fibers (coconut fiber, groundnut shell, and sugarcane fiber) to determine the suitability of these materials as effective sound absorbers in acoustic applications. The experiment seeks to present the internal workings of the sound absorption mechanism inherent in coconut fiber, groundnut shell, and sugarcane fibers, highlighting the potential as a substitute for synthetic materials. The research aims to utilize its findings to develop eco-friendly insulation materials, integrating natural fiber such as coconut fiber, groundnut shell, and sugarcane fiber. The objective is to mitigate noise pollution in various settings, including offices, libraries, and cafes. The initiative aligns with the worldwide focus on sustainability, addressing the pressing need to combat noise pollution in megacities.

Keywords – Coconut fiber; groundnut shell; sound absorption; sugarcane fiber



Raw agriculture waste materials used in the study: (a) coconut fiber, (b) groundnut shell (c) sugarcane fiber.

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BRINE VALORISATION USING MECHANICAL VAPOR COMPRESSION DESALINATION: APPROACHES TO CONSIDER

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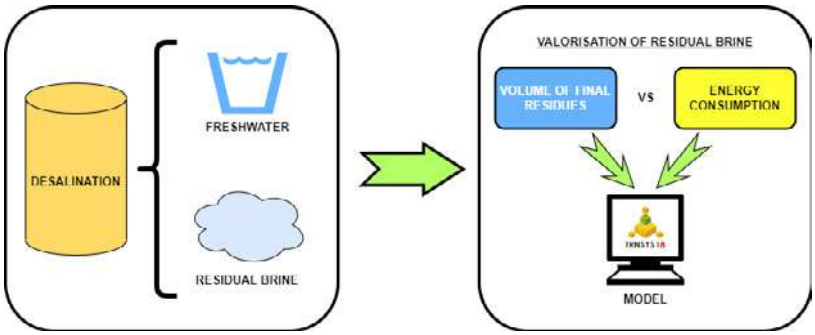
Abstract – Water scarcity is one of the biggest challenges we are facing due to climate change: lack of rainfall and polluted water sources are an increasing reality worldwide. Sustainable Development Goals reinforce the urgency of dealing with this issue, targeting scientific community's efforts towards solutions for this trending topic, where desalination of seawater is one of the main proposals. However, concerns regarding environmental effects of residual brines, generated in the desalination process, are emerging on the spots where this technology has been applied.

To contribute to the implementation of desalination technologies, the valorisation of these residual brines brings the opportunity not only to reduce the volume of wastewater generated, but increasing its final concentrations and producing more freshwater from a residue. Nevertheless, it comes with the cost of higher energy demands than in the previous stage: the higher the concentration of the fluid, the higher its energy consumption. The authors can approach this challenge from two different perspectives – focusing on the final amount of concentrated residue, or focusing on the energy demand of the installation.

While focusing on reducing the volume of residue to its minimum expression is the most attractive option for concentrating the dissolved salts, it comes with the cost of excessive energy demands. On the other hand, focusing on reducing the power consumption of the installation allows the usage of variable renewables in a more efficient way, allowing the carbon neutrality of emissions during its operation but obtaining a lower concentrated residue. By using a computational model of the installation, we can replicate its operation and compare results from both perspectives.

This paper looks at the usage of two scenarios with fixed conditions for a basic mechanical vapor compression (MVC) desalination plant modelled in TRNSYS, where we can observe the correlations between the final volume of residual brine and the energy consumption required for achieving those results. One of the scenarios will show the biggest final concentration, while the other one will consider the minimum operating conditions for the desalination plant. Apart from those results, there will be an analysis of environmental and economic advantages that can be achieved by the implementation of this technology as well as an early approach towards the technical aspects involving the development of the model used for these calculations.

Keywords – Carbon neutrality; energy efficiency; model; seawater; sustainable development goals (SDGs); TRNSYS



General ideas regarding to the presented valorisation of brine approaches.

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Moreover, this work has been developed during an internship at Riga Technical University (RTU) in order to start the transfer of knowledge between campuses of the European University of Technology (EUT+), thanks to all the researchers that have contributed to my integration in your campus.

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QUANTIFICATION OF LOST RESOURCE POTENTIAL OF UNSORTED TEXTILE WASTE

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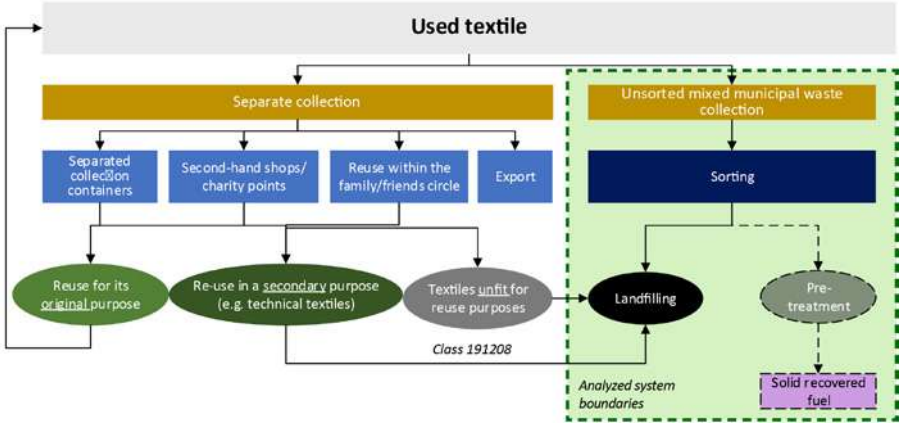
Abstract – The European Union (EU) requirements for the separate collection of textile waste came into force in Latvia in 2023. As part of the measure, containers for the management of separated textile waste were placed in locations accessible to the public, alongside other types of separately collected waste (e.g., glass, plastic and cardboard). The containers were designed to collect textile waste that met the following requirements:

- Shoes and clothes must be clean, dry, and free of chemicals, motor oil stains and mold.
- Free from damage (holes, tears, etc.).
- Soft toys, fabric scraps and rags, shoes that are no longer a pair or are damaged, torn or have holes, as well as home textiles, are not allowed to be stored in containers.

This means that the national textile waste collection system is limited only to textiles that can be reused without additional repair or pre-treatment (e.g., washing) and the developed national textile waste collection system supplements the private initiatives existing through clothing donation points and second-hand shops. However, there is a 'shadow' zone related to textile waste that do not meet the abovementioned collection requirements and are not specifically regulated and managed so far at a country level, thus have to be collected in unsorted household waste containers. The objective of the present research is to quantify the amount of textile waste collected from unsorted mixed household waste containers and to quantify the physical condition and fibers of this waste. Subsequently, the environmental impact of the lost resource potential of the unsorted textile waste based on the obtained quantitative and qualitative waste data was defined via life cycle indicators.

Keywords – Cloth scarps; environmental impact; indicators; life cycle assessment; mixed household waste



System boundaries (marked as a green square) of the survey.

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WHAT HAVE WE LEARNT SO FAR ABOUT THE EXTENDED PRODUCER RESPONSIBILITY – RESULTS OF BIBLIOGRAPHIC REVIEW

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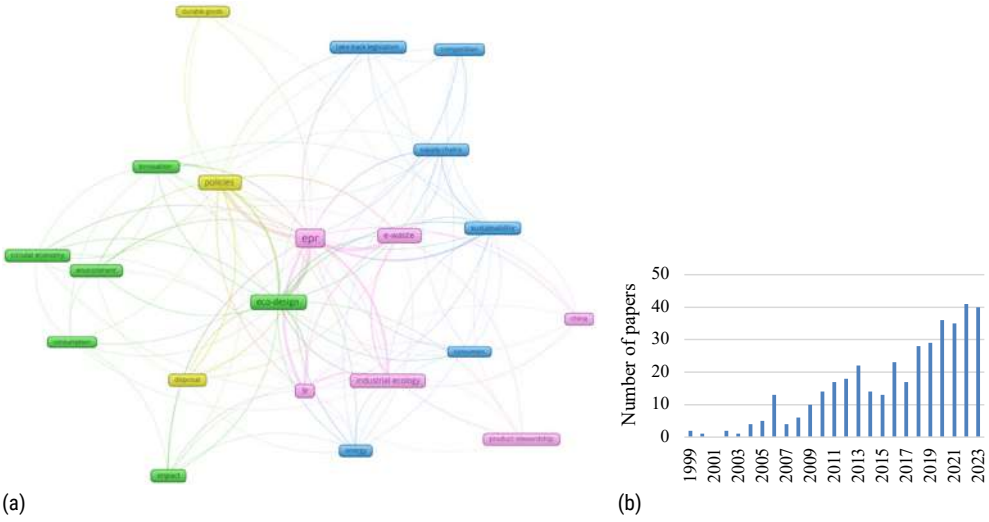
Abstract – Nowadays, the environmental impact of the manufacturing sector, particularly in terms of waste management, is receiving increased attention. In this context, the extended producer responsibility (EPR) has become an essential environmental policy instrument for all European Union (EU) Member States. This policy principle has also garnered interest from other countries around the world, which recognize its importance. The EU has acknowledged the effectiveness of this instrument and seeks to enhance the sustainability and waste management practices within its manufacturing sector. The operational principles of EPR are regulated at the EU level collectively, while also allowing for individual definition by each Member State. It is important to note that these principles encompass measures primarily aimed at promoting waste prevention, reuse, recycling and other forms of recovery. The aim of this paper is to provide an in-depth insight into the operational principles of the EPR in the EU Member States, its application to different product groups and identify the existing challenges related to assessing the effectiveness of the EPR system via bibliographic review of scientific papers published in Web of Science indexed journals.

Keywords – Circular economy; EPR; policy; product end-of-life; waste



(a) (b)

Bibliographic analysis of EPR systems ((a)– co-occurrence of keywords, (b) – chronology of the EPR related scientific papers in Web of Science).

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MOVING WASTE SECTOR TOWARDS CLIMATE NEUTRALITY. SCENARIO ANALYSIS

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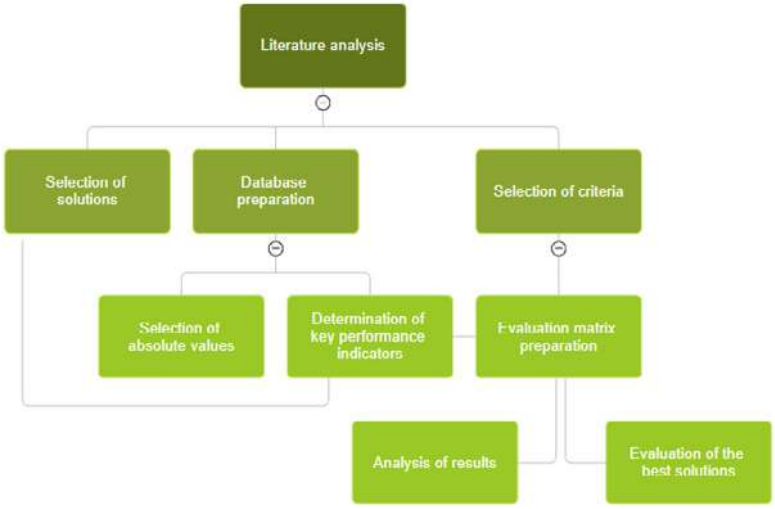
Abstract – The upward economic growth, the development of the industrial, transport and agricultural sectors, and technological innovations contribute to the constant stimulation of the demand and supply of new products and services, inevitably contributing to the increase in the amount of waste. Mitigation of climate change is not a short-term goal; therefore, sustainable and reasonable practices in the waste management sector could contribute to positive changes in mitigating GHG emissions and climate change in general. However, it is not clear whether by implementing the current domestic waste management policy of Latvia and the action measures contained in it, it is objectively possible to achieve the strategic goals and desired results set at the European Union as well as at the national level, what is the impact of the set goals and the success of their implementation so far, and whether these political settings will not remain only at the level of ideas and wishes. In the scientific literature, several proposals developed as a result of research have been put forward for reducing the climate neutrality of the waste sector with the help of various technologies and technological innovations. At the same time, it is difficult to evaluate the proposals and solutions put forward in the research results in relation to an individual situation; for example, if a municipality in Latvia would like to implement it in order to evaluate their effectiveness, benefits and applicability. Difficulties are caused by the research results presented in the scientific literature, which are not expressed as indicators that would help to apply this solution to each individual case and its characteristic values. The purpose of the study is to evaluate the political goals set by Latvia in the household waste management sector in the context of the political goals set by the European Union for achieving climate neutrality and to provide an objective assessment of the achievement of the goals set by Latvia. In order to achieve the goals, an analysis of the scenarios of the household waste management sector established by Latvia's policy will be carried out, an evaluation of the actions implemented as a result of the policy and still planned will be carried out. Also, in order to achieve the goals of the study, indicators will be developed, with the help of which the effectiveness and applicability of the implementation of various technological innovations could be assessed. The development of indicators will be based on the information reflected in the scientific literature about the results of the implementation of technological innovations in the household waste management sector. As a result of the literature analysis, the absolute values of the selection of criteria for the implementation of technological innovations will be determined, as well as key performance indicators will be determined in such categories as technological solution, economic factor, impact (mitigation) on the environment, social factor. The scientific novelty of the research is based on the creation of a value database of the criteria for the implementation of technological innovations and the development of an evaluation matrix based on it, based on the collected indicators, which would help to assess the applicability and availability of the technological innovations introduced in the waste management sector in order to

promote the goals set in the political documents for achieving climate neutrality. As a result of the research, an assessment of the compliance of the climate neutrality goals set in the political planning documents will be carried out based on the indicators included in the developed matrix in order to achieve the best waste management solutions.



Methodology of evaluation matrix development and research structure based on it.

Keywords – Waste; waste management; climate changes; climate neutrality; impact on the environment; key performance indicators; evaluation matrix

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EFFICIENT LOW-TEMPERATURE NUTRIENT REMOVAL FROM AGRICULTURAL DIGESTATE USING MICROALGAE

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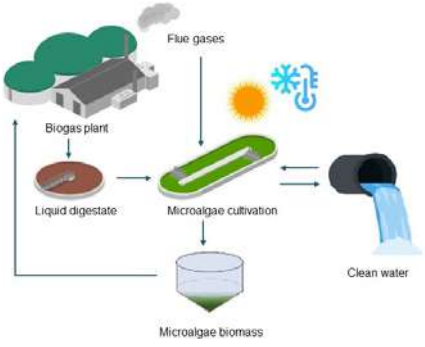
Abstract – Humanity is facing an energy crisis triggered by the depletion of fossil fuels, rapid industrialization, and the growth of the global population. These trends put an emphasis on searching for alternative energy sources. Additionally, the rising concentration of carbon dioxide in the atmosphere is driving climate change, which poses serious threats. In this scenario, microalgae emerge as a promising solution for both sustainable energy production and CO_2 sequestration. Digestate, a nutrient-rich by-product of anaerobic digestion, is considered a cost-effective nutrient source for microalgae cultivation. Utilizing digestate not only enhances the sustainability and economic feasibility of microalgal biofuels but also offers a method for wastewater treatment. Nevertheless, the application of digestate is limited by its high optical density and substantial number of total solids. In this study, several pretreatment methods were tested to increase the feasibility of digestate application for microalgae cultivation. Our findings show that various centrifugation methods and vacuum filtration decrease the content of total solids but are not effective in reducing optical density. Although the use of microalgae in treating various wastewaters has shown promising outcomes, the effectiveness of nutrient removal at low temperatures remains largely unexplored. To fill this gap, green microalga *Chlorella sorokiniana* was cultivated in pretreated diluted liquid digestate in dynamic springtime weather conditions in a covered open race-way pond integrated into a biogas plant. During the cultivation, high solar irradiance and low temperatures were recorded resulting in suboptimal conditions for *C. sorokiniana* growth. Although low productivity of *C. sorokiniana* was detected, the nutrient removal efficiency was high. *C. sorokiniana* could efficiently remove 83 % of nitrogen and 85 % of phosphorus, showing very promising results of the use of microalgae for wastewater treatment in high latitude regions.

Keywords – Bioeconomy; biogas; biomass; Chlorella sorokiniana; circular economy; open raceway pond; wastewater treatment



Nutrient removal from agricultural digestate by integrating microalgae cultivation into a biogas plant offers a closed-loop circular economy perspective also in low-temperature regions.

ACKNOWLEDGEMENT

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