CONECT 2023

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RIGA TECHNICAL UNIVERSITY

XVI International Scientific Conference of Environmental and Climate Technologies

BOOK OF ABSTRACTS

10–12 May 2023 | Riga, Latvia

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XVI International Scientific Conference of
Environmental and Climate Technologies

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CONECT 2023 CONFERENCE

It is a great pleasure to welcome you to the CONECT 2023 – XVI International Scientific Conference of Environmental and Climate Technologies.

CONECT Conference has been held since 2008. The conference annually brings together scientists, researchers, PhD students and professionals from all over the world. The purpose of the conference is to acquaint participants with recent achievements in energy systems and environmental engineering, as well as to give them an excellent opportunity to share experiences and publish research results. The three-day event brings together an impressive line-up of speakers from more than 20 countries around the world.

CONECT offers Plenary and Panel sessions on the following, but not limited with, topics:

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- District Heating
- Energy Efficiency
- Renewable Energy Technologies
- Biotechnologies
- Low Carbon Development and Bioeconomy
- Bioresources
- 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.

In addition to Plenary and Panel sessions, the CONECT conference hosts a number of social events, including: Innovative Industrial Pilot tour, poster session and virtual exhibition, scientific workshop, social dinner and more.

The conference is organised by RTU IESE and takes place every year in the second week of May.

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This is testified by the unwavering interest of partners to cooperate with us both in research sectors well-balanced in climate technologies and resilience, energy and environmental policy, environmental governance and energy management and resolution of engineering-technical issues in industrial, agricultural, energy and waste management companies through the application and adaptation of various computer models in process simulations.

Lately, systems dynamics modelling has become that which is most prominent both for mathematical description and simulation of processes, as well as for the analysis of policy instruments in many sectors of the economy. Research on increasing the energy efficiency in buildings, including biomimicry and studies on problems related to the heating of historical buildings, are also in demand, as well as on heating and mass exchange technologies, including drying, burning and gasification, the main influence being placed on the scientific research of innovative technological processes. The guarantee for the sustainability of the IESE is in searching for new areas which results in interesting future projects. In the past years, our experience has allowed us to acquire more in-depth knowledge of bioeconomy and research its role in the development of a country, its regions, and society.

Without a doubt the balanced advancement in the IESE scientific research capacities is made sustainable through cooperation with strong partners in Latvia, the European Union member states, Norway, the USA, Colombia, Canada, Taiwan, India, and other countries. We participate in joint projects within the Baltic Sea Region, HORIZON, and the Nordic Energy Research programmes, which have resulted in investments in the development in environmental science and engineering and have contributed to resolving environmental and engineering issues. We continue to be open to new cooperation in research and studies.

At the IESE we set ambitious goals and are convinced that we can reach them.

JOURNAL OF ENVIRONMENTAL AND CLIMATE TECHNOLOGIES

The journal Environmental and Climate Technologies is an international scientific journal, which is published by the RTU IESE. The journal provides international publicity for original research and innovative work. It covers a variety of topics for all aspects of Environmental science:

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- Climate technologies,
- Climate change and resilience,
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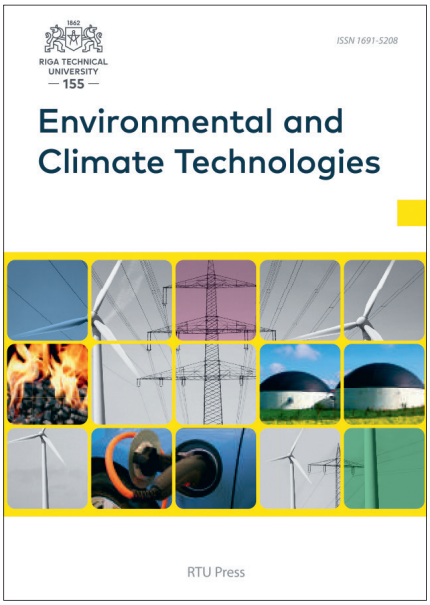

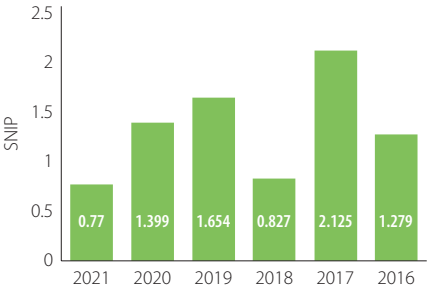

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At the same time, the Embassy promotes cultural and educational exchanges between the two countries by facilitating study-abroad programs, hosting exhibitions, and encouraging other cultural and educational events.

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01

ENERGY EFFICIENCY, ENERGY SYSTEMS

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ASSESSING THERMAL COMFORT PERCEPTION IN THE CONTEXT OF SOCIAL HOUSING. CASE STUDY IN NORTHERN SPAIN

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Abstract – The influence of people on building performance in terms of energy efficiency and environmental impact is becoming increasingly significant. It is essential to include users' perspective, their comfort and satisfaction in decision making to ensure not only their well-being, but also the feasibility of interventions and the adequate performance of the building stock. Furthermore, understanding residents' level of thermal satisfaction can enable more appropriate measures to improve the energy efficiency of buildings. Although there are several methods for studying thermal comfort, such as qualitative analyses based on surveys or perceived comfort indices such as PPD and PMV, thermal satisfaction is susceptible to the subjectivity of the responses. It may be necessary to contrast different indices or methods. This study aims to define an indicator that measures the level of thermal satisfaction of social housing occupants so that it can be contrasted with other methods of analysis of perceived comfort and can be replicated in different building contexts. A way to analyse users' thermal satisfaction is proposed in a quantitative way, measured as the difference of the desired temperature and the perceived indoor temperature. The index is applied to a sample of 283 social housing dwellings in the Basque Country, Spain, with the data obtained via surveys that include questions on thermal comfort in winter and households' characteristics. The thermal satisfaction has been analysed and the results have been contrasted with the perceived thermal comfort in winter and the household's capacity to maintain the dwelling at the desired temperature. Moreover, it has been observed whether there may be energy vulnerabilities by contrasting the satisfaction result with the income and expenditure per person in the household. The obtained variable provides occupants' opinion and perception to ensure the suitability of the solutions for improving the energy efficiency of the building and the thermal comfort. It is also possible to apply it to different building typologies and compare the results with other models of perceived thermal comfort.

Keywords – Built environment; occupant perception; thermal comfort; satisfaction; social housing

Acknowledgement

The authors would like to acknowledge the Public Society Alokabide, Viviendas Municipales de Bilbao, SestaoBerri and the company STECHome for their support and contribution, as well as for the information, access and monitoring data provided. Ethics approval from Ethics Committee for Research on Human Subjects, CEISH-UPV/EHU, BOPV 32, 17/2/2014, was obtained before conducting the study. This research work will form part of a Doctoral Thesis carried out by S. Perez-Bezos, funded by the Call for tender for a researcher training at the University of the Basque Country UPV/EHU 2019 [PIF19/139].

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APPLICABILITY OF THE ASSESSMENT FRAMEWORK ON BUILDING RENOVATION OF THE EUROPEAN UNION IN SPAIN

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Abstract – The energy renovation of buildings is one of the main keys to achieve the decarbonisation objectives of the European Union as defined in the European Green Deal. To proceed with them, some of the main tools are the Energy Performance of Buildings Directive (EPBD) and the Commission Recommendation (EU) 2019/786, with an assessment framework composed by Measurable Progress Indicators (MPIs) to assess the decarbonisation process of the national building stock of the Member States. The objective of the study is to analyse the applicability of the MPIs of the assessment framework in Spain. The study carries out deep research of the viability of the MPIs in terms of data availability as well as a round table of 39 experts from different national organizations focused on the energy efficiency of buildings. Thus, the methodology is developed in three stages: (1) the analysis of the viability of each MPI in the Spanish context in terms of data availability; (2) prioritization of the MPIs through a round table of experts in energy efficiency of buildings; (3) critical evaluation of the priority MPIs regarding the efficient applicability in Spain. Firstly, the analysis of viability shows that it is possible to develop most of the MPIs of certain evaluation scopes, like 'Overview of policies and actions to target the worst-performing segments of the national building stock' with 6 out of 7 MPIs viable; however, in some other scopes very few or none of the MPIs are viable, like in 'Policies and actions to target all public buildings'. Secondly, the expert round table prioritized 8 as the most important MPIs to evaluate the renovation of the national building stock, addressing different evaluation fields like environment and energy, renovation progress, social measures, and integration of technologies. Thirdly, the evaluation of the selected eight priority MPIs show that half of them is not viable in Spain according to the data availability, one partially viable, and only three of them are viable, but with limitations in the data quality; in the viable MPIs, the available data sources that allow the processability, exist only for two of them; georeferenced data exist for none of them. In conclusion, the MPIs of the EU's assessment framework provide convenient indicators to assess the renovation of the national building stock according to the expert round table, but due to the data availability, it shows a limited applicability in the context of Spain.

Keywords – Decarbonising; Energy Performance of Buildings Directive (EPBD); European policy; long term renovation strategy (LTRS); Measurable Progress Indicator (MPI); National building stock

Acknowledgement
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Contribution statement. Markel Arbulu: writing, resources, methodology, investigation, formal analysis, data curation, conceptualization. Xabat Oregi: validation, supervision, resources, project administration, investigation, funding acquisition, conceptualization. Markel Rueda: writing, resources, investigation. Belinda López-Mesa: validation, methodology, resources, project administration.

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BEYOND WELL-BEING: THE ASSESSMENT OF THE ENERGY RENOVATION IN LATVIA BY THE RESIDENTS

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Abstract – The renovation of the multifamily buildings represents a key policy area and at the same time largely affects the daily life of residents. In the time of energy crisis, when energy price rises and saving energy becomes especially important, the building sector is among the most affected and a key sector to mitigate the consequences. The paper tackles the energy renovations of multi-family buildings in Latvia that use energy performance contracts. Specifically, it investigates how the process of renovation affects the residents' health and well-being, their perception, and understanding of the renovation process. To evaluate the perception of the residents, a survey was conducted in thirteen buildings renovated by using energy performance contracting in three cities in Latvia. The survey addressed the preparation and execution of the energy renovation project, the state of the building before and after the renovation, and the impact of the renovated building on the residents. The survey revealed the lack of communication between the parties involved and co-design as the roadblocks to upscale the renovation process in Latvia. In particular, the financial communication to the residents on the project costs was insufficient. Additionally, even though the residents' perception of safety, health, and comfort improved, the survey shows a decrease in communication between the residents of the same building after the renovation. Assessment of the survey results reveals the need to improve the communication by the ESCOs on the costs of the energy renovation projects and address the lack of community engagement after it is completed.

Keywords – Energy efficiency; EPC+; ESCO; well-being

Acknowledgement

We would like to express our gratitude to "RENESCO" Ltd for supporting the distribution of the surveys to the residents and providing their feedback in the survey development process. The research was conducted with the assistance of the U.S. Department of State Federal Assistance Award number SLG75021GR3034-M001. The award-providing institution is not responsible or taking part in the formation of information provided in the research paper.

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COST-OPTIMAL SECTOR INTEGRATION AND ENERGY BALANCING STRATEGIES FOR REACHING CARBON NEUTRALITY

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Abstract – Sectoral integration will play a major role in the clean energy transition to increase the utilisation rates of available renewable energy sources (RES). Preliminary studies have shown that the decarbonisation of power generation can be reached through well-developed technical solutions such as the integration of hydro, wind, and solar energy. However, emissions in the buildings, transport, and industrial sectors remain stubbornly high. Therefore, the electrification of these sectors and interconnection through smart grids have been identified as promising future development trends to avoid the usage of fossil fuels. The TIMES optimisation model is used to evaluate the future cost-effective pathways for reaching carbon neutrality in the Latvian energy sector. The model includes both the end-use sectors such as transport, buildings, industry and agriculture and the energy sector with a well-developed database of existing and future RES and storage technologies. The modelling framework allows for identifying the cost-optimal future energy mix by considering the electrification potential of each sector. Therefore, it allows analysing of the impact of different policy strategies at sectoral integration levels and the necessity for additional energy storage capacities. The preliminary results show that one of regret-free solutions for reaching the energy efficiency targets in 2030 is the wide expanse of heat pump utilisation in residential buildings instead of inefficient biomass boilers. The building heat supply transformation also brings higher power consumption and interacts with the wider utilisation of wind power. In addition, sensitivity analyses have been performed to evaluate the impact of high uncertainties related to fuel costs, resource availability and other conditions.

Keywords – Carbon neutral energy generation; energy storage; sectoral integration; renewable energy sources

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ENERGY AUDIT AND ENERGY MANAGEMENT SYSTEMS: REVIEW OF INTERNATIONAL ENERGY AUDITING PRACTICE

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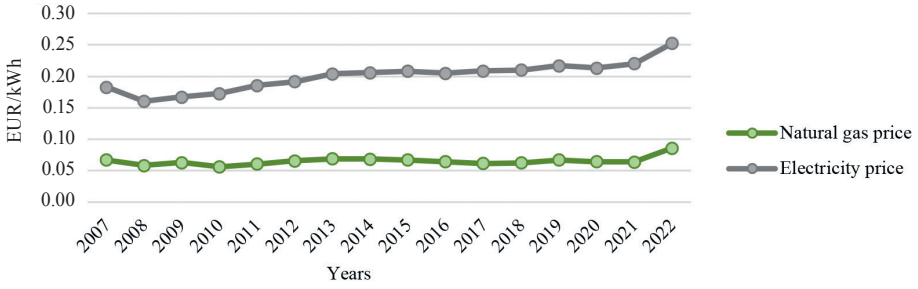
Abstract – This research combines the analysis of international knowledge in energy audit practices with the information on the nature of energy audit and its involved parties on the path to fulfilling the goals set by the European Union policy and Latvian national policy. The article also analyses the publicly available information about the energy sector in Latvia, industry statistics, and legislative acts that have a direct impact on the implementation of energy audits. Although the European Union aims to reduce the EU emissions by at least 55 % by 2030 and to reduce gas demand by 15 % by May 2023, sustainable energy use requires not only increased renewable energy production, but also an efficient and competent use of this energy. The article first assesses the institutional basis, by EU regulations, to promote energy audits in the country. International energy audit and energy efficiency practices are also reviewed, focusing on government policy, energy audit standards, tools and methods. As each member state of the European Union has independently interpreted and adapted the EU requirements related to energy efficiency, the exchange of information between member states on their knowledge and experience should be considered an essential aspect of the policy, so that in the future countries together could achieve European energy security, independence, competitiveness and sustainability by adopting the best examples. The result achieved in the research is a summary of the energy audit experience of the EU and other countries, a description of energy consumption and their prices in Europe, as well as an extract of the most important regulatory acts.

Keywords – Emission reduction; energy consumption; resource efficiency; sustainability



Natural gas and electricity prices for household consumers, average in the EU, years 2007–2022, EUR per kWh.

Acknowledgement

This study is part of the author's Master's Thesis "Management of the bioeconomy. Bio audit", which is being developed at the Riga Technical University, in the study program "Environmental Engineering".

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EVALUATING THE FEASIBILITY OF HYBRID VENTILATION IN EDUCATIONAL SPACES: A SIMULATION STUDY IN THE NORTHERN BASQUE COUNTRY CLIMATE

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Abstract – This paper delves into the examination of indoor comfort in classroom environments and its interplay with ventilation on human wellbeing in scenarios of varying indoor carbon dioxide concentrations. The assessment of these parameters was done according to the provisions outlined in the Spanish national Regulation of Thermal Installations in Buildings (RITE). This study also compares various ventilation strategies, namely natural, mechanical and hybrid ventilation, commenting the pros and cons of each method in the climate of the Basque Country, Spain. To do so, a classroom in the School of Architecture of San Sebastián was modelled in thermal simulation software. Simulations were carried out for full days in 5-minute intervals using Design Builder, and considered in three different exterior scenarios (a cold day, temperate day, and a warm one) and three different ventilation systems (natural, mechanical with heat recovery, and hybrid). Two additional scenarios where added for control, one with no ventilation at all and another with a partial, constant, natural ventilation, like it was done during the COVID-19 pandemic. Thus, the natural ventilation option was evaluated under three conditions (windows always closed, windows open 15 %, and windows operated by thermal sensation of the user). The mechanical system evaluated consisted of a constant flow ventilation for IDA 2 IAQ with an airflow of 12.5 l/s·person. The modelled hybrid system consisted in a combination of simple flux mechanical ventilation and open windows and doors under some particular conditions. An occupancy rate of 50 % of the theoretical maximum occupancy of the classroom and a heating setpoint of 15 °C were considered. This article presents the CO_2 concentration, final energy consumption and thermal comfort results obtained in the simulation and compares between different scenarios. The results showed that the hybrid ventilation system was able to effectively control indoor air quality, providing a healthy and comfortable environment for occupants. The hybrid system demonstrated improved energy efficiency compared to the natural ventilation system, while maintaining a high level of indoor air quality. Overall, the results of this study highlight the importance of considering hybrid ventilation in educational spaces in the northern Basque Country climate. The study provides valuable insights for building design and operation, especially for renovation of existing schools and educational facilities that lack any means of mechanical ventilation, showing some of the potential for hybrid ventilation to improve indoor air quality and energy efficiency.

Keywords – Indoor air quality (IAQ); human-building interaction; hybrid ventilation; natural ventilation; schools; thermal comfort

Acknowledgement

This research was funded under the title “Proyecto Piloto Sobre Calidad del Aire en Espacios Interiores Universitarios” in the Campus Bizia Lab program 2022–2023, promoted by the Directorate of Sustainability, Vice-Rectorate for Innovation and Social Commitment of the University of the Basque Country (UPV/EHU).

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EVALUATION OF THE DATA CENTRE WASTE HEAT POTENTIAL IN DISTRICT HEATING IN LATVIA

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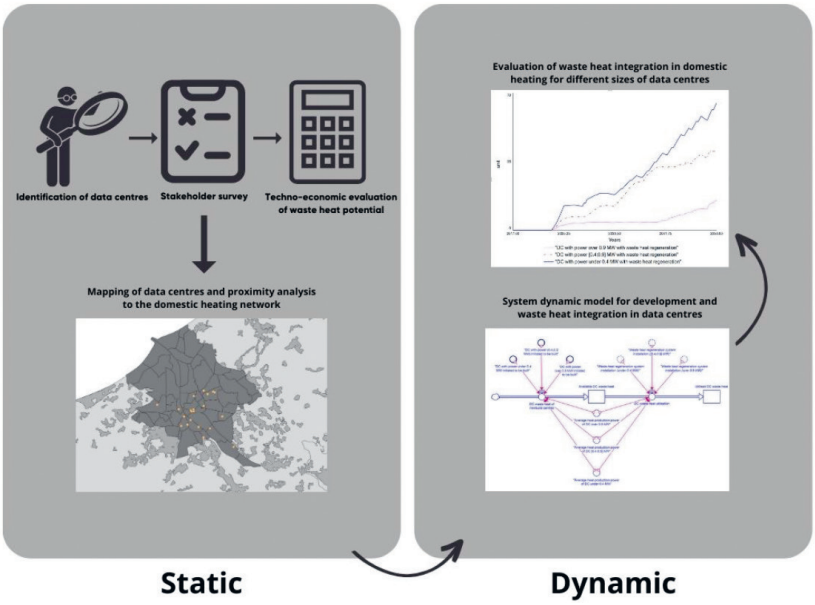
Abstract – Data centres are large global energy consumers that create low-temperature waste heat. To alleviate the impact of the temperature increase on the information technology equipment, the data centres are cooled with different technical solutions, drastically increasing the facilities' power consumption. In different regions, the use of data centre waste heat combined with heat pumps in district heating systems was identified as a lower-cost heat energy generation solution compared to alternative fossil or renewable energy-based heating solutions. The research paper aims to identify the data centre's waste heat potential as an energy source in district heating in Latvia. The technical and economic potential for using heat pumps in the data centre's waste heat systems was evaluated. To reach the goal of the study, a mixed methodological approach was used divided into four steps: the creation of the statistical calculation method, stakeholder survey to evaluate the energy consumption, mapping of the quantitative results to evaluate technical potential and distribution patterns, and system dynamics modelling to evaluate possible adoption scenarios of the technological solutions. The results of the research reveal a heterogenic distribution of data centres in Latvia, which limits the use of waste heat at the national level. Furthermore, the study identified the total waste heat potential of data centres in Latvia and provided recommendations for the adoption of data centres' waste heat based on the results of the system dynamic simulations.

Keywords – Data Centre; district heating; heat pumps; renewable energy; waste heat



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EXPLORING THE CONTROL OF THE POSITION OF THE ISOTHERMS OF THE HEAT PUMP CYCLE IN AN AIR HANDLING UNIT: AN EXPERIMENTAL STUDY

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Abstract – The use of heat pumps in the building heating and cooling supply chain is increasing, and air-to-air heat pumps are increasingly being installed in modern air handling units. The energy conversion modes of such devices are constantly changing due to the constant change in the state of the outdoor air (temperature, humidity). Flexibility, the ability to efficiently and rationally respond to ambient air parameters, is an important feature of choosing the operating mode of energy transformers and their control. The overall seasonal efficiency of the air handling unit depends on it. Modern commercial heat pumps have two control degrees of freedom. They have a variable-speed compressor and an electronic expansion valve. This combination of control components once made it possible to increase the seasonal efficiency of heat pumps. For a long time, the possibility of controlling the cycle in this way prevailed, and only electronic control tools were improved. Little attention is paid to how the changes in the thermodynamic cycle are combined with the energy demands of air preparation corresponding to the outdoor temperature. It would be relevant to look for additional components of the heat pump circuit that could control its operating cycle, which could increase the efficiency indicators of the air preparation process. The article's authors seek to introduce an additional component into traditional measures of heat pump control, providing the third degree of freedom of the control cycle. For this purpose, studies are being conducted to experimentally assess the impact of the volume of the heat pump system on the shifts of the isotherms of its thermodynamic operating cycle. The results show that the system volume parameter has the potential for regulation capabilities in controlling the operation of a heat pump, so it is worthwhile to further develop and study such a technological solution in more detail.

Keywords – Air handling unit; control; eat pump; experimental study; isotherms; vapor compression cycle

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EXPLORING THE DIFFERENTIAL EFFECTS OF URBAN HEAT ISLANDS ON ENERGY USE AND CARBON EMISSIONS IN WARM AND COLD CLIMATES: A CASE STUDY OF NORTH AFRICA AND NORTH EUROPE

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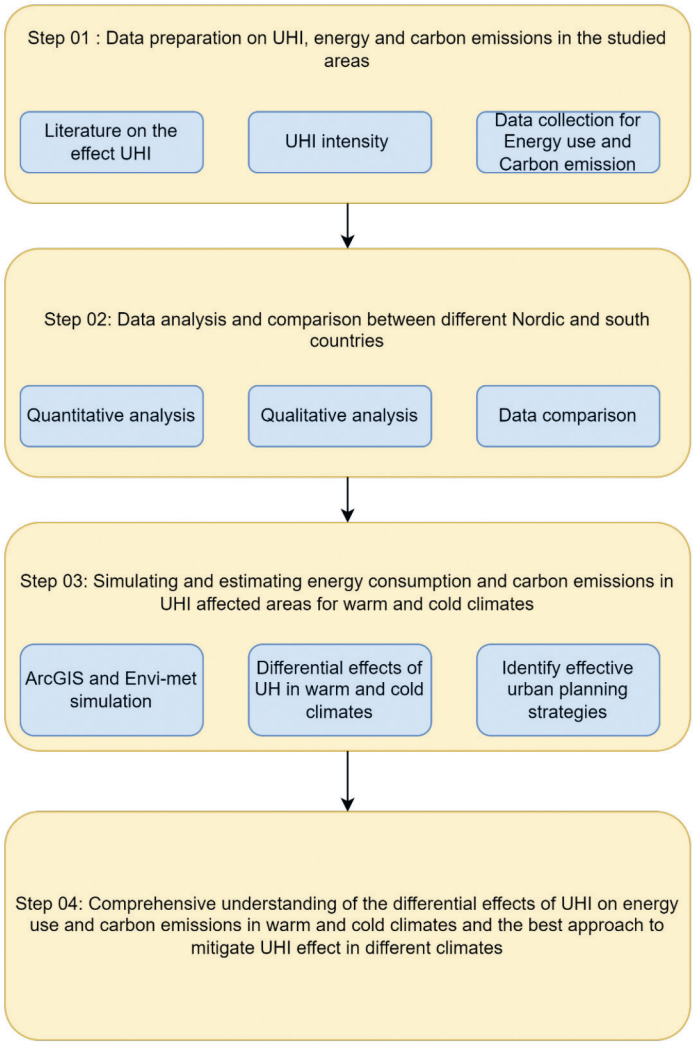
Abstract – The urban heat island (UHI) phenomenon has differential impacts on energy use and carbon emissions in buildings depending on the climate of the region and the urban planning strategies in place. This study explores the differential effects of UHI on energy use and carbon emissions in warm and cold climates, using North Africa and North Europe as case studies. We address the following research questions: 1) How does the UHI phenomenon impact energy use and carbon emissions in buildings in these regions? 2) What urban planning strategies are currently in place to mitigate the negative impacts of UHI on energy demand and emissions in these regions? 3) How effective are these strategies in mitigating the negative impacts of UHI on energy demand and emissions in both warm and cold climates? 4) What additional urban planning strategies could be implemented to reduce further the negative impacts of UHI on energy demand and emissions in both warm and cold climates? The UHI increases energy bills and emissions due to the higher demand for cooling energy in warm climates, while in cold climates, UHI reduces energy demand and emissions by decreasing the need for heating energy. Urban planning strategies, such as incorporating green space, using reflective materials, choice of colors, and designing for natural ventilation, can effectively mitigate the negative impacts of UHI on energy demand and emissions in both warm and cold climates. However, the effectiveness of these strategies varies depending on the climate of the region and the specific urban context. In this study, we will provide a recommendation for urban planning strategies that can be implemented to further reduce the negative impacts of UHI on energy demand and emissions in both warm and cold climates. Our study contributes to the understanding of the UHI phenomenon. It provides insights for urban planners and policymakers in developing effective strategies to reduce energy use and carbon emissions in buildings and cities.

Keywords – Geographic information system (GIS); residential energy consumption; urban heat island (UHI); urban heat island effect; urban planning



Methodology of the study.

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FACTORS INFLUENCING RESIDENTS TO IMPLEMENT ENERGY EFFICIENCY MEASURES IN MULTI-APARTMENT BUILDINGS

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Abstract – The review examines in detail the types of factors that may influence residents' motivation to implement energy efficiency measures in multifamily housing. When analyzing heating energy consumption in multi-apartment buildings, three influencing factors must be considered: the condition of the building, technology-based solutions, and occupant behaviour. Studies show that in more developed countries, energy consumption of buildings can be reduced by 30 % to 80 % if energy efficiency is improved. Technology based solutions aim to reduce heat consumption, improve resource productivity, or replace outdated technologies, but these solutions often require large investments. Occupant behavior contributes to nearly 80 % of the variation in energy use. One of the ways to achieve these goals is to improve energy efficiency in multifamily buildings, because according to available literature, residential and commercial thermal energy consumption accounts for up to 20 % of total energy consumption in underdeveloped countries and up to 40 % in more developed countries. Changing people's habits not only reduces heating energy consumption, but also does not require large investments for implementation.

Keywords – Energy consumption; energy efficiency; multi-family buildings; occupants behaviour

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HEAT ACCUMULATION WITHIN BUILDING ENVELOPES TO SUPPORT TRANSITION TO LOW-TEMPERATURE DISTRICT HEATING (LTDH)

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Abstract – The novel feature is to consider the transition process when the low-temperature mode is switched to the ordinary high-temperature operation. It takes place when time of relatively high heat demand starts – in the beginning of winter. The contribution to the pool of knowledge is that we consider building envelopes that have previously been charged before the system starts operating at a full load; this results in relatively low indoor temperature drop compared to the reference scenario. The control logic formulated considers low temperature concept and other technologies available (e.g. heat accumulators) running at the same time. This pattern is compounded by the recommendation to set 50 °C during fall and spring, when the average outdoor 5-day temperature is 0 °C and above. The main result is O&M cost reduction by 19 %, achieved by incorporating low-temperature with 50–60 °C operating temperatures and using centralized storage. The maximum storage capacity ensures a 16-h long delay in transition to the normal operating mode, if all the studied buildings are involved to limit drastic flow rate increase and minimum indoor temperature is 0 °C to prevent damage to SH system. However, such low values are never encountered in practice and represent the upper threshold only, since usually supply temperature increase takes up to 5 hours. Besides, the weather forecast is typically accurate, and all the actions are typically taken in advance – several hours prior to the outdoor temperature drop. The considerations are general enough to be applied to other areas of the DH system. To sum up, the operational pattern of the supply temperature for 6 typical buildings located in Omsk was studied using the reference-group based approach. As DH systems are in a transition phase to 4GDH, there is a tremendous potential and possibility for emerging novel DH designs, which address all the issues and expectations of future distribution networks including competitive performance and cost-effectiveness. The similarities among buildings were measured on the basis of pointwise and the same distributional distance based on their indoor temperature data. The methodology suggested in this paper, which uses reference-groups, has been proven as a pertinent solution and highly efficient; however, it can still be further improved to be not sole, but rather incorporated in the idea of combined low- and temperature-flexible operation. So far, the analysis based on the stability proportion criterion was performed to recommend the best substation's valves adjustments and identify the best combination of material/height/substation type for constructing office or residential buildings.

Keywords – Demand; district heating; efficiency; heat consumption; load; optimization; space heating; supply; temperature; thermal

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HEATING SYSTEM CONTROL WITH NEURAL NETWORK

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Abstract – Buildings have a significant impact on humans' life and ecology, as buildings account for 39 % of total greenhouse gas emissions and consume about 40 % of total global energy. Smart building control is one of the key points to achieve high energy efficiency. Each year, the complexity of building state control grows due to the increase in the number of controlled elements that are used to achieve better indoor climate. Therefore, in the manual analysis and implementation of the building control program, the possibility of errors is high due to the human factor. Artificial intelligence (AI) algorithms could be used as an alternative solution. They could evaluate building dynamics independently. One of the strategies for automatic building control adaptation to its dynamic is a model-based predictive control, where neural network is used for different control strategies evaluation. Performance of such control technique is highly dependent on control strategies evaluation accuracy. To achieve the top accuracy, several hyperparameters of neural network could be tuned. In addition, a data set for specific construction should be prepared. The preparation of the data set could cause a problem because random control of building for generation of dataset could be not acceptable for building users; it could also damage the construction. In this paper authors process optimization of experimental building heating system control algorithm to achieve smaller fluctuations of temperature indoors. For dataset generation several data were used from weather station, as well as heating system parameters and temperature indoors. The building was controlled by thermostat with the built in PID regulation. For evaluation of building dynamics was used temporal convolutional neural network. To achieve high accuracy results of control strategies evaluation, several hyperparameters of neural network were tested. The final model was tested on a physical building. The results indicate that in some cases the developed control model could prevent temperature fluctuations which could be caused by limits of heating system power.

Keywords – Artificial intelligence; building control; heating system

Acknowledgement

This study was conducted with the financial support of ERAF project "Development and approbation of complex solutions for optimal inclusion of CHE in nearly zero energy building systems and reduction of primary energy consumption for heating and cooling" (1.1.1.1./19/A/102).

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IMPACT OF CLIMATE CHANGE ON THE HEATING DEMAND OF BUILDINGS. A DISTRICT LEVEL APPROACH

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Abstract – In the 21st century, the importance of energy generation and carbon emissions in developing countries is indisputable. In the whole wide world, the building stock is responsible for the two fifths of the total world annual energy consumption. Considering the predictions regarding future climate due to climate change, a good understanding on the energy use due to future climate is required. The aim of this study was to evaluate the impact of future weather in the heating demand and carbon emissions for a group of buildings at district level, focusing on an area of London in the United Kingdom. The methodological approach involved the use of geospatial data for the case study area, processed with Python and Anaconda through Jupyter notebook, generation of an archetype dataset with energy performance data and TABULA typology and the use of python embedded in QGIS to calculate the heating demand in the reference weather data, 2050 and 2100 in accordance to RCP4.5 and RCP 8.5 scenarios. A validated model was used for the district level heating demand calculation. On the one hand, the results suggest that a mitigation of carbon emissions under the RCP4.5 scenario will generate a small decrease on the heating demand at district level, so similar levels of heating generation must continue to be provided using sustainable alternatives. On the other hand, following the RCP 8.5 scenario of carbon emission carrying on business as usual will create a significant reduction of heating demand due to the rise in temperature but with the consequent overheating in summer, which will shift the energy generation problem. The results suggest that adaptation of the energy generation must start shifting to cope with higher temperatures and a different requirement of delivered energy from heating to cooling due to the effect of climate change.

Keywords – Energy performance; future climate scenarios; geospatial data; OS MasterMap; TABULA typology; Urban Building Energy Modelling (UBEM)

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INCREASING SUSTAINABILITY IN VOCATIONAL EDUCATION SYSTEM: LATVIA CASE STUDY

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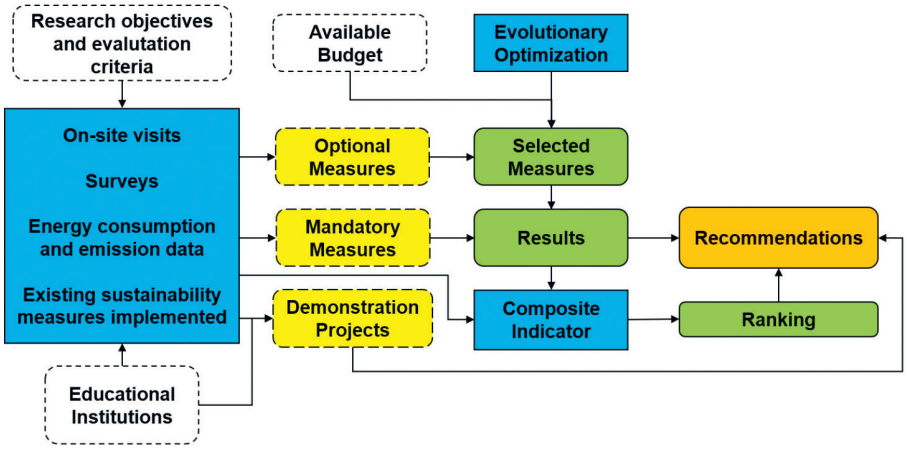
Abstract – Promoting sustainability in educational systems is crucial for preserving resources and diminishing negative impacts on the environment. A key aspect of this is enhancing energy efficiency and renewable energy use within educational institutions. This research paper aims to explore ways to increase sustainability in Latvia's vocational education system. A study of 23 educational institutions has been conducted to understand the current state of sustainability in the educational system, including data collection on energy consumption and surveying the institutions on their current energy efficiency practices, renewable energy sources, and environmental policies. The energy efficiency and renewable energy production measures have been optimized for each school. A composite indicator has been developed to rank and compare schools based on their sustainability, promoting the use of energy-efficient and renewable energy sources within a limited budget. Results of the study show that by implementing mandatory and optional measures, educational institutions can significantly decrease primary energy consumption by 39 % and greenhouse gas emissions by 34 %.

Keywords – Composite indicator; energy efficiency; environmental impact; greenhouse gas emissions; optimization; policy; primary energy consumption; renewable energy; survey

Acknowledgment

This study has been funded within the framework of agreement No.03000-3.1.2.2-e_75 agreed upon by Riga Technical University and the Ministry of Education and Science of the Republic of Latvia on September 30, 2022.



Research methodology.

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INVESTIGATING THE PERFORMANCE OF THE COMPACT PARTICULATE MATTER COLLECTOR FOR USE IN DOMESTIC WATER SYSTEMS

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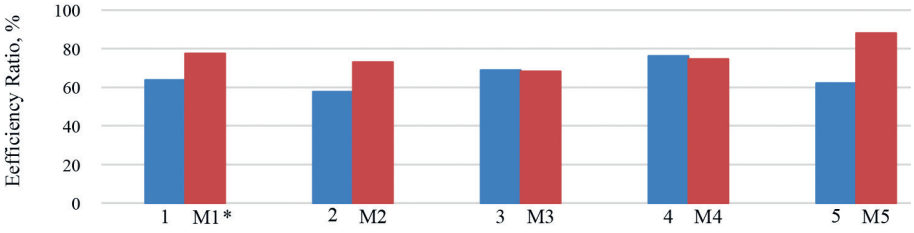
Abstract – The concept of the new water treatment system was developed. The system is based on the previously invented technology – Compact Particulate Matter Collector (CPMC). A primary area was defined in which such technology is intended to be used: water treatment in compact flue-gas condensation systems for a low-power wood-fuelled biomass boiler. Such a system is intended for use in domestic conditions. Such a process involves contamination of technical water with a mixture of particulate matter, resulting in suspension. The CPMC aims to divide the suspension into the relevant fractions effectively. A prototype operating based on CPMC technology was built. An experimental plan was developed, and an experimental stand was constructed to determine the prototype's efficiency. The experimental plan envisaged five different prototype operating modes and two research steps, depending on the degree of prototype modification. Based on the research results, it was concluded that the prototype could operate effectively in the laboratory environment: achievable efficiency is equal on average between 57.84 % and 88.09 % depending on the operating mode (see the diagram below). The result is assessed as positive. TRL 3 has been reached. The next phases of the study would be the integration of the prototype into the relevant compact flue-gas condensation system and the exploration of commercialisation capabilities, which will stimulate TRL increase.

Keywords – Biomass energy; domestic water treatment; efficiency study; laboratory testing; particulate matter; prototype development; water filtration; water purification



Average efficiency ratio depending on the CPMC operation mode (* M – modified prototype used).

Acknowledgement

This work has been 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" of the Specific Objective 8.2.2 "To Strengthen Academic Staff of Higher Education Institutions in Strategic Specialization Areas" of the Operational Programme "Growth and Employment".

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MOBILE THERMAL ENERGY STORAGES AS COMPLEMENTARY TECHNOLOGY TO DISTRICT HEATING NETWORKS

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Abstract – District heating networks (DHNs) are an important backbone of today's heat supply with high potential to contribute to a reduction of greenhouse gas emissions, if their heat sources are increasingly transformed into renewable ones. However, an economically viable application of such networks requires adequate occupancy rates and power density along the lines because the infrastructure causes significant effort in terms of investment, operation and maintenance. This is one of the reasons why DHNs are mostly implemented in urban regions. On the other hand, industrial plants are not always located within the meaningful range of DHNs, although they require huge amounts of heat as well as release significant amounts of waste heat, depending on the specific industrial sector. The utilisation of mobile thermal energy storages (M-TES) can be a possibility to close the gap of energy transfer between a DHN and the industry or even directly between two or more industrial plants. The intention of this approach is to transfer heat by charging a mobile heat storage at the producer and transfer it to the consumer by means of common transport and available infrastructure, e.g. by a truck on the road. In this way, the M-TES concept could serve as a complementary heat supply technology for regions without DHN or it could even be a competitor to DHN for the case that it might by economically advantageous. M-TES was already investigated in the past, even by experimental implementation, but with the energy prices of 2015 it was financially not feasible. As energy markets had to face unknown fluctuations in 2022, the research work presented in this paper had the aim to analyse the M-TES concept for the current situation. Therefore, a comprehensive economic evaluation was performed, based on VDI2067, for calculating the levelised costs of heat (LCOH) for M-TES. This investigation was done for the three main types of heat storing mechanisms, namely, sensible, latent and thermochemical storages. In each category, several material types were considered to meet possible requirements of the specific application, e.g. in terms of temperature demand. This updated analysis of M-TES yielded positive results for thermochemical and latent heat storages, as the LCOH are significantly lower compared to the heat costs of DHN in Austria in 2022. However, the transportation distance is the most sensitive parameter in this study, which restricts the viability of M-TES to near surroundings.

Keywords – Economic evaluation; heat transfer network; industrial excess heat; waste heat recovery

Acknowledgement

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MULTIDIMENSIONAL FACTORS INFLUENCING RENEWABLE ENERGY STORAGE DEPLOYMENT: PESLTE ANALYSIS

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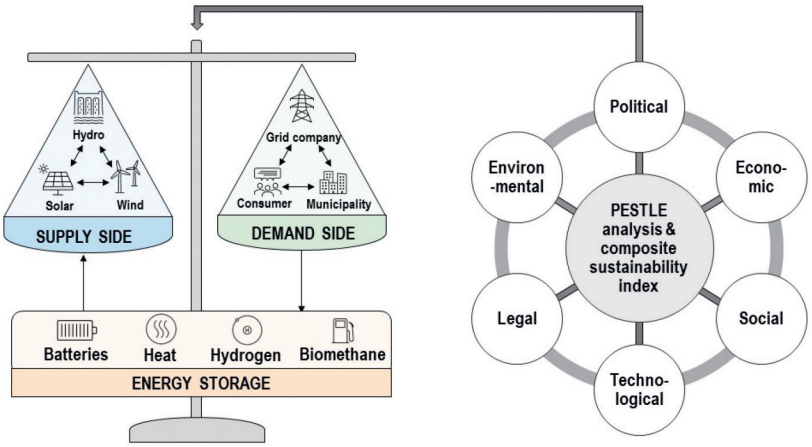
Abstract – The share of renewable energy in heat and power generation is expected to increase significantly and reach record levels in the coming decades. As a result, emerging energy storage technologies will be key elements in balancing the energy system. Compared to power generation technologies, storage technologies are considered one of the most complicated and least understood technologies for decarbonizing the energy system. There is still lack of understanding among scientists and policymakers about the choice of optimal integration of energy storage in carbon-neutral energy systems, as there are many multidimensional factors that influence this. In this study, the PESLTE analytical framework and composite index methodology is applied to examine the multidimensional factors that influence the deployment of renewable energy storage technologies: political (national and international level policy targets, appropriate regulation), economic (CAPEX, LCOE), social (public acceptance, knowledge and on-site capacity on RES storage in local energy supply enterprises), legal (level of bureaucracy and time of approval), technological (TRL, response time, efficiency level of complexity for technology to be integrated in the existing grid), and environmental (specific need for specific geographical condition, landscape friendliness, potential environmental risk, potential creation of environmental benefits, lifetime of technology, environmental impact).

Keywords – Composite index; energy storage; indicators; renewable energy; sustainability



PESTLE analysis framework for renewable energy storage technologies.

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NUMERICAL MODEL AND SYSTEM FOR PREDICTION AND REDUCTION OF INDOOR COVID-19 INFECTION RISK

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Abstract – Airborne aerosol transmission is a significant route of SARS-CoV-2 and other viruses in indoor environments. The developed numerical model assesses the risk of a COVID-19 infection in a room based on the measurements of temperature, relative humidity, CO_2 and particle concentration, as well as the number of people and occurrences of speech, coughing, and sneezing obtained through a dedicated low-cost sensor system. As the model operates faster than real-time, it can dynamically feed this information back to the measurement system or building management system, and it can activate an air purifier with filtration and UV-C disinfection when the predicted infection risk is high. This solution enhances energy efficiency as (1) lower ventilation intensity is necessary in the cold season to reach the same safety level and (2) the purifier is activated only if the predicted infection risk is above a certain threshold. The model is integral and takes into account the average values of simulated variables. However, it considers the inhomogeneous vertical distribution of concentration of droplets and aerosol particles. The droplets expelled by a potentially infectious person at a certain height through breathing, speaking, coughing, and sneezing are characterized by the total amount of expelled liquid, droplet size distribution and virus particle concentration. The rate of droplet evaporation depends on the temperature and relative humidity. Droplets are redistributed within the room vertically through turbulent diffusion and gravitational force. If the final droplet diameter is less than 5 mm, these particles are considered airborne and can leave the room only by ventilation, filtration, or by sedimentation on surfaces through Brownian diffusion. As a person in the room inhales these droplets and aerosols, the risk of infection increases as the number of absorbed virions grows, with the probability of infection being 50 % when 300 virions have been inhaled. The parameter studies using the model indicate that the coughing and sneezing events greatly increase the probability of infection in the room, therefore, the identification of these events is crucial for the applied measurement system. A method for determining the unknown ventilation intensity by measuring the number of people and the CO_2 concentration is proposed and tested.

Keywords – COVID-19; infection risk, numerical modelling

Acknowledgements

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PHYSICAL, CHEMICAL, AND BIOLOGICAL ASPECTS OF INDOOR AIR IN UNIVERSITY CLASSROOMS

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Abstract – Nowadays there is a challenge to provide a good indoor air quality because of the energy crisis, distance working and climate changing circumstances in premises. The aim of the study was dedicated to biological, chemical and physical parameters of air quality, such as temperature, the concentration of carbon dioxide (CO_2), particulate matter (PM2.5 and PM10), and their fluctuations in a university classroom during ongoing classes. Measurements were taken for three days (November, 2022) in two different size rooms with natural ventilation using devices such as: *SAS SUPER ISO 100* (microbiological sampling), *Aranet4* (temperature, concentration of CO_2), *PCE-PCO 1* and *PCE-RSCM 16* (PM2.5 and PM10). In total, 52 microbiological samples were collected from university classrooms over three days and further cultured on different growth mediums. Students' activity, windows opening and closing times were recorded during the study. The colony forming units per cubic meter (CFU/m^3) overall fluctuated between 174 and 934 CFU/m^3, with fungi making up the majority. The CFU/m^3 for fungi grown on *Sabouraud agar* was 24–610, for bacteria grown on *Trypticase soy agar* (TSA) 42–476, and for bacteria grown on *Mannitol salt agar* (MSA) 42–254. The study concludes that according to guidelines, the recommended amount of microbiological contamination should be less than 500 CFU/m^3. The indoor temperature for smaller rooms exceeded the allowed indoor air temperature of 25 °C after on average 50 minutes, while for the largest it remained below 25 °C level. The highest concentration of CO_2 for the first day was 2689 ppm, for the second day – 1970 ppm, and for the third day – 2131 ppm. Performing the ventilation for 20 minutes on average decreases the CO_2 concentration to 499 ppm. According to guidelines, CO_2 concentration should not exceed 1000 ppm in premises, but this level was reached on average after 25 minutes following window closure and the ongoing class. Natural ventilation alone was found to be insufficient for ongoing classes and effective during breaks, but other pollutants such as PM2.5 and PM10 enter the room in this way. The main findings reveal the tendency of both PM2.5 (on average 400 μg/m^3) and PM10 (on average 35 μg/m^3) to increase rapidly in crowded spaces during the classes, which require a constantly running air ventilation and purification system. However, there is a lack of regulations or guidelines regarding the maximum concentration of PM and microorganisms CFU in indoor air in public places.

Keywords – Air quality; indoor; outdoor

Acknowledgement

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POSSIBILITIES OF APPLYING ACOUSTIC METHOD AND ELECTRICAL ENGINEERING FOR ACOUSTIC WAVE FLAME EXTINGUISHING BASED ON THE LATEST EUROPEAN RESEARCH: BENEFITS, DEVELOPMENT PROSPECTS AND LIMITATIONS

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Abstract – The article analyses the possibilities of using acoustic technology for extinguishing flames from various sources. Advantages as well as disadvantages of acoustic technology are presented. The structure of this article shows different approaches, methods, as well as application of acoustic waves for fire extinguishing. In the light of the latest research, the state of the art is presented (literature review) and the prospects for the development of technology using low cost intelligent sensors are shown. The second aspect of fire management is fire detection. In practice, the use of a subdiscipline of machine learning, in which the learning process is carried out in an unsupervised way – deep learning, is a modern alternative to flame detection in relation to classical temperature or smoke sensors. In this case, it is possible to benefit from the advantages of technologies described in this article by combining the use of these techniques.

Keywords – Electrical engineering; environmental technology; firefighting; flame extinguishing; intelligent sensor

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POTENTIAL ROLE OF HYDROGEN IN DECARBONIZATION OF DISTRICT HEATING SYSTEMS: A REVIEW

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Abstract – District heating (DH) will have an increasingly important role in the decarbonization of energy systems and improving the security of supply. Although the electrification of DH via heat pumps and heat storage is seen as the main path to decarbonization, green hydrogen could also be an important energy source for covering peak demand, providing long-term storage in power-to-gas solutions and backup. The research question of the study was to identify the potential pathways for replacing natural gas in DH with hydrogen. Should we focus on using pure hydrogen and build appropriate infrastructure, or should we use hydrogen-derived synthetic gas, for which we already have an infrastructure? The chosen method for this study is a review of publications. The results show the existing technological solutions and associated costs for using either hydrogen or hydrogen-derived synthetic gas, i.e. methane.

Keywords – Cogeneration; decarbonization; hydrolysis; methane; renewable energy; sabatier reaction; synthetic gas; sustainable energy systems

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PROFILE OF HARD-TO-REACH ENERGY CONSUMERS: DEFINITIONS, NEEDS AND BARRIERS

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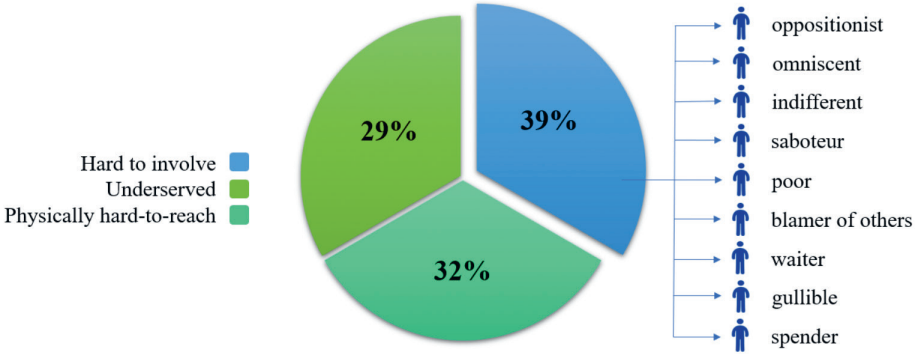
Abstract – According to the European Union, household energy consumption accounts for up to 30 % of total energy consumption. Therefore, the household sector has the great potential for reducing greenhouse gas emissions. The introduction of energy efficiency measures and the renovation of multi-apartment buildings are important solutions for greenhouse gas emissions reduction and achieving climate neutrality in Latvia. However, this potential is not being fully exploited because the renovation process in the multi-apartment building sector is extremely slow. One of the reasons for this is the lack of interest and willingness of residents to engage and agree on the implementation of energy efficiency measures in buildings. The study examines the main groups of energy consumers, their definitions, needs, as well as the most common obstacles and barriers that prevent energy consumers from fully engaging in the implementation of energy efficiency measures. To get an idea of the groups, publicly available information on the characteristics of hard-to-reach consumers was analysed, media content was analysed and interviews with energy experts were conducted. The results showed that the literature mentions different definitions, audience characteristics, barriers, and needs of hard-to-reach energy consumers. These definitions, barriers, and needs vary across countries and research contexts. There is a strong focus on overcoming barriers but little research on the needs of the groups. Defining the audience accurately and studying the needs of the groups in depth are essential steps in developing and implementing appropriate policies for engaging hard-to-reach energy consumers. These findings highlight the important knowledge gap in this research field.

Keywords – Climate neutrality; energy efficiency in buildings; energy efficiency policy; energy users; underserved consumers



Hard-to-reach energy consumers in residential buildings.

https://doi.org/10.7250/CONECT.2023.023

RANKING OF ELECTRICITY ACCUMULATION POSSIBILITIES: A MULTICRITERIA ANALYSIS

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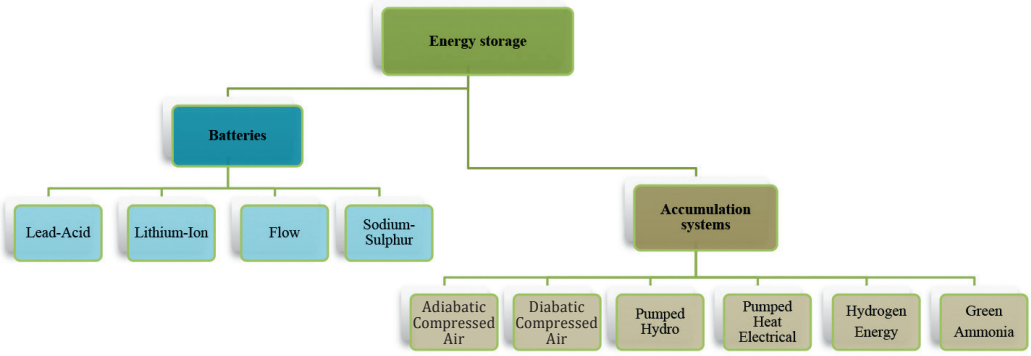
Abstract – The pace of implementation of renewable electricity storage in Europe is disappointingly slow due to several factors. There is a need to speed up the rate and increase the volumes in order to promote a 100 % transition to renewable energy resources, expand the practice of using renewable energy, and contribute to the improvement of the user's quality of life. In addition, a significant reduction of the global impact on the environment and climate change is an important factor. Electricity from renewable energy sources, such as the sun and wind, has a seasonal nature that cannot provide the necessary electricity for consumption and cannot cover peak loads. Also, the so-called 'energy resource crisis' is a topical issue, which reinforces the global need to increase the share of renewable energy resources in the overall balance of primary energy resources. It is precisely the wider integration of renewable electricity storage in practice that can help stimulate this. The availability of renewable electricity is constantly increasing, and the level of technological innovation is rapidly developing. Therefore, it is crucial to analyse both phenomena and actively search for overlaps in developing technologies, not forgetting the main differences in the types of accumulation, to promote accessibility, starting from a private house to the national and European scale. This article analyses and compares the options for renewable electricity storage – from small batteries to large storage systems. The authors consider the best solutions to satisfy individual and collective needs of the consumer. In this article, a multicriteria decision analysis (MCDA) and TOPSIS are used as analysis tools. After comparing nine criteria, such as the investment required, existing power density, efficiency, duration of operation, and others, in both groups, it is concluded that lithium-ion batteries are currently the best solution among batteries; while in the group of large accumulation systems pumped hydro storage secures a superior position.

Keywords – Energy; decision making analysis; innovations; TOPSIS; renewable; storage



Compared electricity storage technologies.

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REGULATING THE UNKNOWN: THE CASE OF COOLING TECHNOLOGIES ACROSS AFRICA

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Abstract – The impacts of climate change and the resources to adapt to it are unequally distributed. Africa, the hottest and poorest continent, is already being adversely affected by rising temperatures; a trend that will continue. Building climate resilience is a bigger challenge in Africa than anywhere else. When it comes to climate adaptation, cooling technologies – including fans and air conditioners (AC) – have been shown to improve the quality of life. In rapidly urbanising and warming Africa, the widespread deployment of cooling technologies could save millions of lives in the coming decades. At this point, however, AC adaptation rates in Africa are only in the single digits with less than 5 %. In contrast, 88 % of households in the US, the country with one of the highest AC penetration rates, have an air conditioner. This is about to change as the number of air conditioners and cooling fans in Africa are expected to double this decade. We should therefore expect an exponential increase in the demand for electricity for these technologies in the coming decades. This raises the important question of where Africa will be on the AC energy efficiency frontier. At this point, Africa imports most of its cooling technology from global companies in China, Japan, South Korea and the US. The quality these companies choose to offer in the current African market will shape the continent's equipment stock and electricity demand for years to come. There are currently only a few regulations in Africa encouraging the diffusion of energy-efficient cooling technologies. Worse still, there is a lack of basic information needed to introduce the right regulations. The aim of this paper is to show that consumers currently have limited access to information about the energy consumption of the cooling technologies available in Africa. To demonstrate this, the authors built a novel database by scraping Africa's largest e-commerce platform in 13 different countries over a period of more than three years. Overall, it was found that less than 10 % of all ACs offered (N = 1382) have information related to energy consumption. In addition, we discovered that the disclosure of this information is highly idiosyncratic and does not appear to have strategic goals. In particular, it is unlikely that only the most efficient AC models would provide the information and that the communication of energy information in the market would occur without government intervention.

Keywords – Africa; climate change adaptation; energy efficiency in buildings

Acknowledgement

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RENEWABLE ENERGY COMMUNITY'S BARRIERS AND IMPACT ON CENTRALISED ENERGY PRODUCTION

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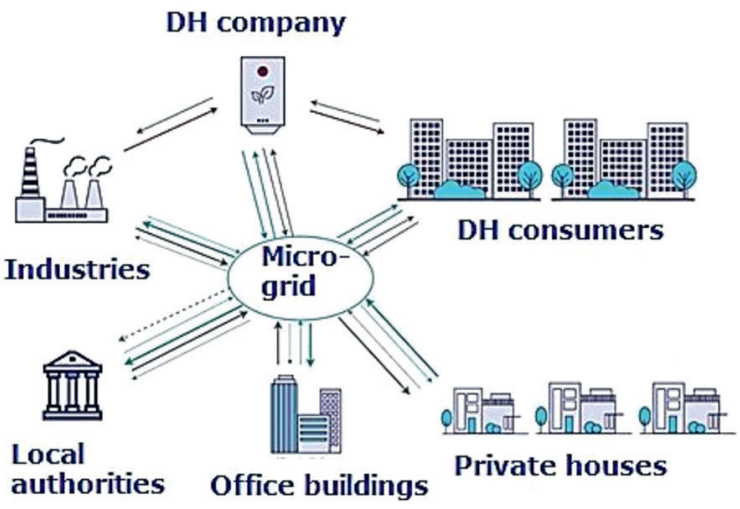
Abstract – Major changes are taking place in the energy sector. In order to achieve climate neutrality, it is crucial to increase energy production from renewable energy sources. One way to accomplish this is to establish energy communities and cooperatives, which require optimal development and expansion solutions. Energy cooperatives are, by definition, community projects whose primary goal is to generate electricity and heat for their own use as well as for sale and distribution. The main reasons for establishing such communities are to reduce costs and the negative impact on the environment, as well as to democratise and decentralise production, reducing reliance on larger producers. This kind of collaborative effort also allows people who lack the necessary funds and knowledge to participate in the production of renewable energy. The goal of energy communities is to use energy produced primarily from renewable energy sources; the easiest way to do this is to use solar panels, but there are also other options. Although the European Union has launched several programmes to increase the number of energy communities, there are several barriers that prevent them from being established. In the conditions where energy communities are connected to largescale energy systems, it is also important to assess how energy communities affect centralised energy production and overall energy efficiency. This study provides a thorough analysis of the barriers to establishing energy communities as well as their impact on centralised energy production and overall energy production efficiency.

Keywords – District heating; energy communities; legislation; RES integration



https://doi.org/10.7250/CONECT.2023.026

REVOLUTIONIZING THE BUILDING ENVELOPE: A COMPREHENSIVE SCIENTIFIC REVIEW OF INNOVATIVE TECHNOLOGIES FOR REDUCED EMISSIONS

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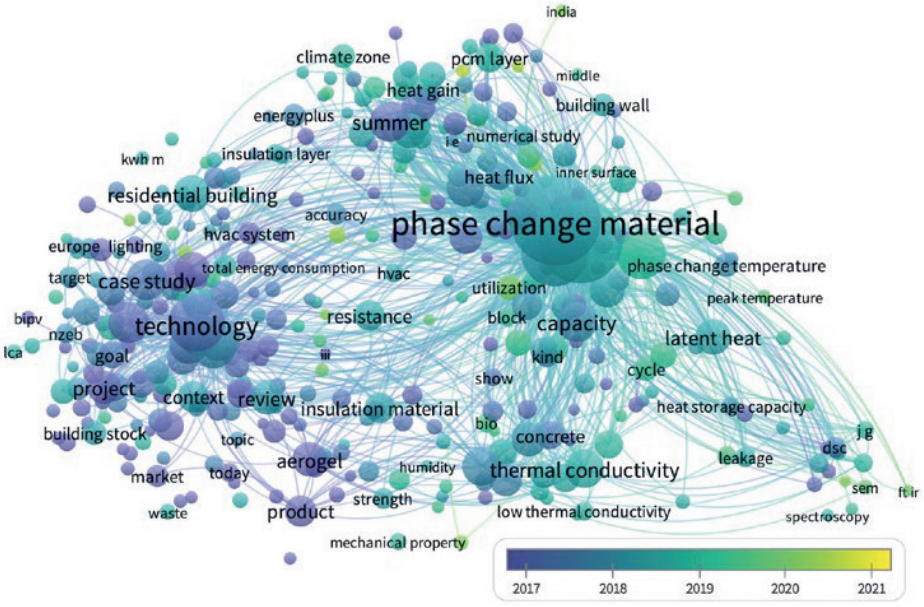
Abstract – The energy and thermal performance of buildings is heavily dependent on the building envelope. As such, innovative environmental building envelope technologies are being developed to improve building energy efficiency and reduce greenhouse gas emissions. This paper provides a comprehensive review of the latest environmental building envelope technologies, such as phase-change materials (PCM), aerogel, and active and adaptive systems, to offer an overview of the current state-of-the-art in the field and identify future research directions. PCM technology has the potential to improve thermal comfort and reduce energy consumption by reducing peak heating and cooling loads. Paraffin wax is the most reliable PCM for use in building envelopes, and studies have shown that it can reduce heating and cooling energy consumption by up to 20 % compared to traditional insulation materials. Aerogel is a low-density and highly insulating material that has been shown to enhance thermal insulation and reduce heat transfer in buildings. Silica aerogel can provide thermal performance up to 2–4 times higher than traditional insulation materials, resulting in significant energy savings of up to 50 %. Active and adaptive systems, such as smart windows and dynamic insulation, allow for real-time control of building envelope performance, further improving energy efficiency and indoor comfort. Smart windows can lead to energy savings of up to 20–30 % compared to traditional windows, while dynamic insulation systems can provide energy savings of up to 50 % compared to traditional insulation materials. The review assesses various adaptive facade solutions based on their suitability for diverse climate zones, versatility in application, global availability of materials used, and energy efficiency. Despite the challenges and limitations of these technologies, including high costs, lack of widespread adoption, and limited understanding of long-term performance, the authors conclude that continued development and implementation of these technologies have the potential to make significant contributions to improving building energy efficiency and reducing greenhouse gas emissions. This review provides a valuable resource for researchers and practitioners working in the field of building envelopes and offers insights into the future research directions necessary to further advance the field.

Keywords – Aerogel; building envelopes; energy efficiency; phase-change materials



The visualization of keywords across innovative building envelope technologies.

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SOLAR PHOTOVOLTAICS IN DISTRICT HEATING AND COOLING SECTOR: AN OVERVIEW

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Abstract – With the prevalent energy scenario and climate changes, decarbonising energy sector has become the need of the hour. An environmentally friendly way is the utilisation of solar energy, which mainly involves the deployment of photovoltaic (PV) panels and/or solar thermal collectors. Unlike electricity generation, the application of photovoltaics in the district heating & cooling (DHC) sector is relatively new. Also, this energy route is not fully explored by scientific community. This paper aims to provide an overview of the photovoltaic application in district heating & cooling sector. At first, the utilisation of solar energy in the DHC sector is briefly described. Then relevant literature in PVDHC is reviewed. It was understood that different topologies are in place for solar energy integration in the DHC system. These topologies vary in terms of the chosen technology, energy storage, system configuration (centralized/distributed) and components. It was found that the research database on the studied topic needs enhancement, with a special focus on PV cooling. From the literature survey, it is deduced that solar PV could play a significant role in future DHC systems due to the possible combination with other energy sources or electric grid or storage technology. Based on the SWOT analysis, it is concluded that there is an enormous opportunity for PV integration in the DHC sector. However, adequate techno-economic support is required to overcome threats and weaknesses. This study is expected to be beneficial to policymakers, researchers and other stakeholders in district energy market.

Keywords – District cooling; district heating; heat pumps; photovoltaics; solar heating

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SUSTAINABLE ELECTRIFICATION AND DIGITALISATION FOR GREENING SMALL AND MEDIUM-SIZED PORTS ALONG THE TEN-T CORRIDORS

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Abstract – Despite the highest competition among the big EU seaports – gateways and hubs, such as Rotterdam, Antwerp, Hamburg or Valencia, etc., which stand for the Core Ports in the European Union (EU) Trans-European Transport Network (TEN-T) Core and Comprehensive Network, the present paper addresses challenges and raises potentials immanent in Small and Medium-Sized Ports (SMSPs) in the EU. Environmental responsibility and digital efficiency – Europe's twin to a green and digital economy paves the way for SMSPs to improve innovation capacity, upgrade demanded future skills and competencies, accelerate EU policies compliant operational, environmental, digital, social, and market performance. The paper deploys a multi-case study approach. Using an ecosystem approach, the paper reveals potentials and pinpoints to key short- and long-term challenges pursuant to SMSPs in the three different EU macro-regions – Baltic Sea Region, AdriaticIonian Sea Region and Mediterranean Sea Region along the four TEN-T Core Network Corridors – Baltic-Adriatic, Orient-East Med, North Sea-Baltic and Scandinavian-Mediterranean. Departing from the role model – Baltic Sea Region – ports of Klaipeda, Wismar, Stralsund and 10 Estonian SPSMs are connected via TEN-T corridors with ports of Bari, la Spezia in Italy and Corfu and Igoumenitsa in Greece. In this vein, knowledge, skills and best practices are transferred from the North Europe to the South and vice versa using the concepts of co-creation and servitisation. Illustrated case studies reveal how all SMSPs are capable to kick-start environmental and digital transition with solutions on Onshore Power Supply (OPS), electrification and digitalisation of port operations through Internet of Things (IoT) and Blockchain solutions used for transport and monitoring operations.

Keywords – Blue economy; green transition; maritime transition; port sector

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THE EFFECT OF THE SPANISH NUCLEAR PHASE-OUT ON THE ELECTRICITY MARKET

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Abstract – Portugal and Spain are integrated into what is known as the Iberian Electricity Market. Spain participates in this market with significant contribution of energy produced by nuclear plants. In 2022, nuclear energy accounted for 22 % of the total energy generated in Spain. Nuclear power plants sell their energy largely through bilateral contracts, and approximately 20 % is offered in the day-ahead electricity market. By 2035, Spain will phase-out nuclear power producing a structural change of its generation mix. In this paper, we investigate the effect on the day-ahead Iberian electricity market that the gradual removal of nuclear power plants will have on the daily electricity market. The methodology is based on a ceteris paribus approach, where generation conditions are modified by removing nuclear plants and keeping the rest of the variables constant (demand and other generation). Under these conditions, the market is reproduced, estimating how electricity prices change in the day-ahead electricity market. To evaluate the market electricity prices under this new scenario with a total or a partial elimination of nuclear energy generation, it is necessary to use a market model. The existing literature shows various approaches to replicate the electricity market, among which are agent-base modelling, optimization algorithms, artificial intelligence techniques or metaheuristic merit-order methods. Our approach is based on the latter methods, by using actual generation and demand data, the new market generation and demand curves are reconstructed and the new clearing price is obtained. For the most conservative scenario, the results show a price increase of more than 5 % for the first 6 months of 2021. The reason for this increase is that nuclear generation participates in the market by offering its energy at prices close to zero. When this generation is withdrawn, there is a shift to the left of the hourly generation curve producing a new market equilibrium at a point of higher price and lower energy.

Keywords – Electricity market; energy transition; nuclear decommissioning

Acknowledgement

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THE INFLUENCE OF YOUNG PEOPLE ON HOUSEHOLD DECISIONS ON ENERGY EFFICIENCY

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Abstract – Young people are the future members of the energy communities and form part of a climate-responsible society already now. However, in the context of the geopolitical and economic events of 2022, the awareness of young people in Latvia about energy efficiency issues and the readiness to engage in climate change mitigation processes, as well as the influence of their attitude on the decisions of adult household members in the field of energy efficiency have not been sufficiently studied. The aim of the study is to evaluate the knowledge of Latvian youth about energy efficiency issues, associations about a climate-responsible society, attitudes towards daily habits in the field of energy efficiency, as well as whether climate change issues are also discussed in young people's families and whether young people believe that they can influence the family's opinion or habits. 71 participants participated in the study, and the methods used are group questionnaires and interviews. The results of the research show that young people in the regions of Latvia are well aware of measures of energy efficiency, and the answers provide an insight into the various experiences they have had in their households. More than half of the research participants between the ages of 14 and 19 are aware of the amount of utility expenses and discuss with their relatives the possibilities of saving energy resources. The research also highlighted negative aspects, for example, concerning to reducing the level of household comfort in the name of climate change, young people are not strongly supporting – only a little more than half would be willing to live in cooler rooms. Young people believe that they can influence the attitude and behaviour of other household members in matters of energy resource management. The results of the study lead to the conclusion that more attention should be paid to messages dedicated to young people in public space, so that they associate themselves more as an existing or future part of the energy community, and they should be given the opportunity to set an example and explain why their actions are important to reduce climate change. The results obtained in the study can potentially contribute to the development of the digital tool designed within the RTU project 'BRIDGE' to promote the development of energy communities.

Keywords – Climate-responsible society; energy community; EU Green Deal; serious games

02

ENERGY AND ENVIRONMENTAL MODELLING

https://doi.org/10.7250/CONECT.2023.031

A DYNAMIC SIMULATION TOOL FOR MODELLING CLIMATE NEUTRALITY SCENARIOS IN MUNICIPALITIES

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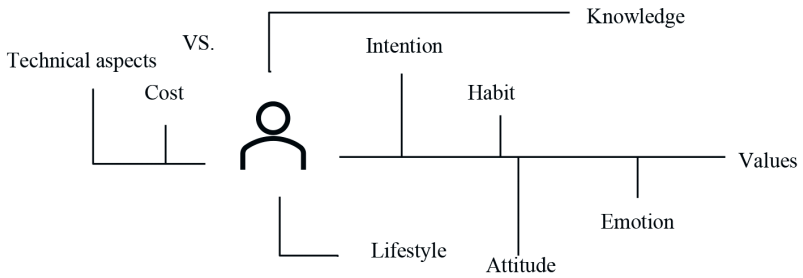
Abstract – Human activities, primarily burning fossil fuels, have increased global temperature at an unprecedented rate since the pre-industrial period. Cities and municipalities have a crucial role in accelerating the decarbonization of economic sectors, since they are at the hub of economic development and progress. The percentage of people who live in cities is expected to rise significantly by 2050, and so do GHG emissions from cities unless urban decision-makers commit to significant improvements. They are in charge of establishing a strategy course to boost energy efficiency, generate renewable energy, and reduce GHG emissions. They are crucial in inspiring communities and stakeholders to promote energy alternatives that are climate neutral. Nevertheless, this potential is not yet fully realized due to a lack of knowledge and helpful tools. It is challenging for municipality representatives to estimate baseline CO_2 emissions, and it is even more difficult to comprehend several potential future situations. This research contextualizes a new computer simulation tool called the CommitClimate Simulator. The tool was developed to help municipalities calculate the carbon footprint and propose a framework for long-term scenario design and future projections. The modeling tool is based on the System Dynamics approach and includes all major GHG emission sectors following international guidelines. The modeling results emphasize the significant impact of behavior change measures on transforming local economies towards climate neutrality. Behavioral change measures are especially crucial in hard-to-decarbonize sectors such as transport. This means that policymakers should not only consider technical or economic aspects in the policy design process, but great care should also be placed on public education and involvement, information and awareness raising campaigns, and fundamental research of energy consumption habits and determining factors.

Keywords – Carbon neutrality; city; climate; energy; GHG; zero emission



Incorporating behavior-related aspects of energy use into modeling climate neutrality scenarios.

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A SUSTAINABILITY-BASED APPROACH FOR GEOTECHNICAL INFRASTRUCTURE

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Abstract – Urban growth needs large cities, and the current emphasis on landscape preservation makes using underground spaces both an opportunity and a significant necessity. However, underground construction techniques significantly impact the sustainability of the built environment, including infrastructure systems and their entire supply chains. Nowadays, there is a shortage of quantitative methodologies to assess and measure the sustainability of underground building processes that effectively integrate the three pillars of sustainability (environmental, social, and economic). Thus, this study aims to solve the abovementioned issues by explaining how to incorporate sustainability goals into geotechnical projects to address measure-driven strategies and eco-design-based solutions appropriately. This study illustrates a novel methodology based on the Life Cycle Thinking approach, with a particular emphasis on geotechnical ground improvement techniques. Specifically, the suggested method incorporates the concept of the EU Taxonomy, following the EU Green Deal, with the Envision framework to guide decision-makers toward a more sustainable, resilient, and equitable infrastructure design. In addition, incorporating a cradleto-grave Life Cycle Assessment (LCA) into the suggested methodological approach will improve the quantitative estimation of the performance of construction processes. The definition of the proposed method will provide the guidelines to systematically assess the sustainability of geotechnical infrastructures to allow further the selection of an optimal solution to reduce their impact from an environmental, social, and economic point of view.

Keywords – Built environment; eco-design; geotechnics; LCA; sustainability; transport infrastructure

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OPTIMIZING BEEKEEPING PRODUCTION THROUGH SYSTEM DYNAMICS MODELING: A CASE STUDY ON FORECASTING BEE QUEEN REARING CAPACITY

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Abstract – Commercial bee queen rearing is an intensive process in which the main commercial product, bee queens, are produced in a short period of time. The intensity is even more severe in regions where the beekeeping season is shorter, as preparation, rearing initiation and capacity increase during the season consume a lot of time. Bee queens can be divided into different product categories: virgin, mated, mated in isolated station, and instrumentally inseminated queens, and they can be further divided by race, pedigree, and colony characteristics. Each category is with varying time and resource consumption. To optimize bee queen rearing and choose the appropriate rearing strategy, product categories, production capacity dynamics, and other aspects, the authors of this case study developed a system dynamics model with the aim of finding the optimal number of production units, the most appropriate product groups and their volumes, according to changes in income and time consumption. The model clearly shows the system's sensitivity to having too many production units – nuclei and queen rearing colonies. Too many production units led to ineffective use of nuclei, increased bee queen mortality, high bee queen surplus, high human and time resource costs and unnecessary batching of orders. The developed model demonstrated how to predict the optimal production capacity and how inefficiency leads to the inevitable collapse of the bee queen rearing system, from which the bee queen breeder cannot recover during the season. The model allowed to conclude that balancing material and human resources in bee queen rearing is very important for efficient production.

Keywords – Beekeeping; bee queens; production capacity; production optimization; queen rearing, rearing strategies; resource management; system dynamics modeling

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AN EMPIRICAL APPROACH TO OPTIMIZE NON-LINEAR PROBLEMS OF DOMESTIC ENERGY MANAGEMENT SYSTEMS

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Abstract – Energy management system for domestic houses comprising photovoltaic energy production and battery electrical storage combined with time-variant electricity prices use to be controlled mean numerical optimization algorithms. The modelling of the system comprises the different involved devices, energy flows and their constrains, and an objective function, which parametrizes the object of the optimization (usually the minimization of the operative costs and/or the CO^2 emissions). The solution of the optimization problem provides the optimal operation (charging/discharging) of the battery along the prediction horizon considered. Power inverter efficiencies are usually modelled by assuming that they have constant values, and hence, that charging and discharging energy-flows lie on the most probably operating region of the inverter. A more realistic modelling of the power inverter efficiencies should consider a non-linear parametrization of the efficiency curves. This consideration converts the optimization problem into a non-linear one. It this paper, we propose a method to solve non-linear optimization problems means iterations of linear optimization problems. At the first step, an optimization problem will be solved by using the values of the efficiencies of the battery inverter provided by the manufacturer for the values. The values of the solution of that problem will be the seed of an iterative process: with help of measured (dis)charging power curves and the optimized (dis)charging energy flows, new values of (dis)charging efficiencies will be determined, and a new optimization problem will be defined and solved. The process stops after a certain number of iterations, or once a convergence is achieved. The results of the experimentation show that the modified method improves the performance of the system by reducing the operative costs with respect to the original method. The results summarized in the table correspond to a whole year with a 15-minutes time resolution and a 24-hour prediction horizon. The second method has the same time-steps, and for each time step triggers an iterative process. Simulations were implemented in Matlab and run on a COREi7 processor (8^{th} generation) platform with 16 GB RAM. A wide experimentation by selecting representative cases with shorter periods (one week) will be done. The main objective of these selected cases is to analyze the dependencies between both methods under different circumstances (seven consecutive days of the year with maximal and minimal solar radiation, seven consecutive days of the year with maximal and minimal standard deviation of the buy and sell prices).

Keywords – Distributed energy resources; energy management; linearization; micro grid; renewable energy; smart grid

Method	Costs, €	Time, s	Time per sample, s
1: constant values	275.61	1961.3	0.056
2: iterative optimization	261.67	6908.1	0.197

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ANALYSIS OF THE INFLUENCE OF POWER SYSTEM DIVERSION ON THE OPTIMAL SUPPLY STRATEGY OF RENEWABLE POWER PLANTS

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Abstract – This paper presents an analysis of the influence of power system deviation prediction on the bidding strategy of renewable generation units in spot markets. The optimal bid that a renewable generator makes is subject to the best possible forecast at the time it submits the energy bid to the spot market, which is usually between 12–36 hours in advance of the time of delivery. With these lead times, renewable generators have to assume a significant volume risk in relation to the difference that may occur between the energy finally delivered and the energy previously committed for their participation in the market, since deviations from the committed energy will be valued at the deviations price. In this sense, the analysis carried out in this work shows that the prices of deviations are highly influenced by the energy needs to be raised or lowered by the system at the time of delivery. In other words, in the event that the deviation of the renewable generator goes against the system, the generator will generally have a higher penalty, having to assume the cost of the energy deviation at a price higher than the spot market price. On the other hand, if the plant's deviation benefits the system, the penalty will be significantly lower (and sometimes even zero). The proposed analysis methodology develops the formulation of the expected benefit of the plant obtained through its participation in the spot market and subsequent settlement of the deviations. This formulation includes the modeling of the effect of the system deviation on the plant's profits, which allows to satisfactorily identify the influence of the prediction of this variable on the optimal offer strategy. This methodology has been tested for the case of a wind farm operating in the Spanish market. For this purpose, real data of forecasts and final production of the wind farm have been used, as well as real data of the spot market, prices of the balancing service and real deviation of the system, which has allowed to verify in totally realistic conditions the importance of the prediction of the direction of deviation of the system in the optimal bidding. In this way, it will be possible to establish new optimal bidding strategies that focus efforts on advanced prediction techniques for this variable, which will result in greater benefits for wind power plants for their participation in the energy markets.

Keywords – Balancing services; electricity markets; optimal energy bidding; renewable energy

Acknowledgement

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CARBON SEQUESTRATION POTENTIAL OF BIOMASS-BASED PRODUCTS: A SYSTEM DYNAMICS MODELING APPROACH FOR GRASSLAND MANAGEMENT

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Abstract – It is known that forests are significant carbon storage, as well as harvested wood products. Both sectors are included in the national greenhouse gas inventories. When wood or other types of biomass grow, it absorbs carbon dioxide through photosynthesis. If biomass is used in the production of new products, the carbon stored in them is effectively removed from the atmosphere and held in the product. Carbon stored in products is considered temporary because the products eventually will burn or decompose and release carbon dioxide back into the atmosphere. However, when products are used for long-lasting applications, the carbon stored in them can remain sequestered for many decades, which can significantly contribute to climate change mitigation. If it is possible to store carbon in wood products, the question arises as to whether it is also possible to promote carbon sequestration in products with other types of biomass. In this work perennial biomass was analyzed. It is a product of semi-natural grasslands, where grass cutting is necessary, which produces grass biomass that is often not fully used. A literature analysis was performed to select suitable products with different carbon storage periods and minimal production emissions, such as those made from biorefining, boards for packaging or building materials, and biochar for soil carbon sequestration. A system dynamics model was developed to estimate carbon stocks and flows between atmosphere, living biomass and products. The base scenario is modeled according to carbon flows in grasslands according to IPCC guidelines – grasslands are net carbon sources and the carbon concentration in the atmosphere only increases. The addition of a product-manufacturing scenario decreases the carbon concentration in the atmosphere.

Keywords –Carbon cycle; carbon dioxide; hay biomass; greenhouse gases; value-added products

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COMPARISON OF MOST POPULAR BUILDINGS PERFORMANCE SIMULATION TOOLS

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Abstract – A critical procedure in sustainable building design is the building energy performance assessment, which has significant implications for global energy consumption and climate change. This study compares three simulation software programs for a photovoltaic system on a building's roof. The low-rise residential buildings in three East Mediterranean cities (Amman, Mafraq, and Aqaba) represent moderate drywarm, semiarid, and humid subtropical climate zones were compared using three simulation software programs (IES-VE, DesignBuilder, REVIT) for a typical building with PV on the roof and the second scenario without a PV system installed on the roof. This investigation aims to evaluate the shading effect of the PV system on a building's roof structure by calculating the total electrical load required to maintain thermal comfort inside the building. The final results showed significant discrepancies between the three software for the base building design and the PV system on the roof, with a range of around 50 %. This highlights the importance of evaluating and calibrating different simulation tools and using them with a great deal of caution.

Keywords – Buildings simulation; DesignBuilder; East Mediterranean; IES-VE; PV; REVIT

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DYNAMIC U VALUE MEASUREMENT FOR INDOOR TEMPERATURE PREDICTION WITH NN

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Abstract – Nowadays, monitoring and automated control are key for the power-efficient and comfortable use of buildings. As the demand for the indoor climate grows, the complexity of building control increases due to the increased number of controlled systems within the building. Therefore, control methods capable of assessing the dynamics of a task and controlling a building independently, are gaining popularity. One of these methods is a model-based predictive control, the energy efficiency of which is directly dependent on the accuracy of predictions of the state of the building. To analyse changes in the dynamics of the internal climate of a building caused by temperature changes, a relatively short history of measurements is needed. However, the analysis of changes in structural properties caused by moisture transfer requires much longer-term historical data. It is known that even neural network architectures with large core memories such as Long Short-Term memory could lose information on large time-series data. In addition, from mathematical point of view, moisture transfer is more complex than heat transfer. As a result, the approximating function for a neural network becomes more complicated, which leads to a decrease in energy performance. To solve this problem, a pre-processing technique to obtain the U value in real time is introduced. The results of a numerical simulation in WUFI6, verified by measurements, showed that the U value of an experimental construction could change by ~10 % due to moisture transfer. The experiments with 3-year monitoring data showed that usage of the proposed method in some cases reduces the average mean squared error of neural network in indoor climate forecast by ~8 %.

Keywords – Artificial intelligence; model-based predictive control; moisture; neural networks; U value; WUFI

Acknowledgement

This study was conducted with the financial support of ERAF project "Development and approbation of complex solutions for optimal inclusion of CHE in nearly zero energy building systems and reduction of primary energy consumption for heating and cooling" (1.1.1.1./19/A/102).

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ENVIRONMENTAL SUSTAINABILITY OF PASTA PRODUCTION: AN EVALUATION THROUGH LIFE CYCLE ASSESSMENT

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Abstract – The recent policy of Green Deal aims to a transition towards 'healthy, equitable and sustainable communities'. One of the key sectors analysed within the Green Deal is the agri-food chain, with the strategy 'From Farm to Fork', aiming to design a sustainable food system from production to consumption, passing through industry processing, distribution and all related activities. At the agricultural level, the objectives are in line with those presented in the United Nations 2030 Agenda, from technologies and digitalization, to organic farming. As for the transformation and distribution phases, the Commission is promoting technological and technical innovation, the restructuring of companies and the improvement of the quality of work. The aim of this study is to perform a Life Cycle Assessment related to one of the main products of a company of the agri-food sector in central Italy. The product analysed is durum wheat pasta. A cradle to gate analysis is performed, starting from the cultivation of the wheat, arriving to the final pasta product. The different transformation steps are evaluated (e.g. cleaning, grinding, compression, extrusion), including the packaging process. The analysis is aimed at identifying the most critical phases along the chain, to plan improvements in terms of efficiency of the production process, with consequent enhancement of the environmental performance.

Keywords – Agri-food chain; environmental impact; Life Cycle Assessment; sustainable production

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IMPACT ASSESSMENT OF STEEL CIRCULARITY SCENARIOS: CASE STUDY OF STEEL RADIATOR BASED ON LIFE CYCLE ASSESSMENT (LCA) METHODOLOGY

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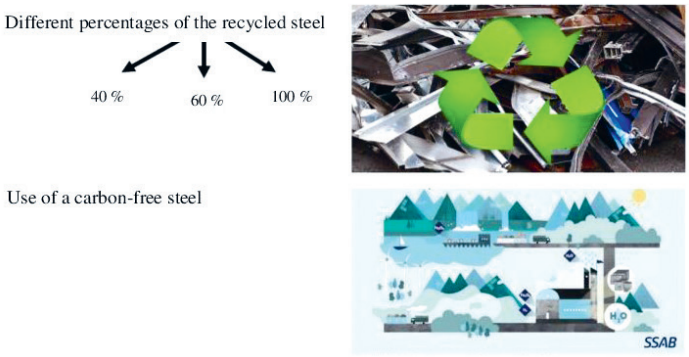
Abstract – Steel is one of the most used materials in the industry and the building sector. Its production causes severe environmental impacts due to direct emissions within extraction and processing stages (e.g. CO, SO_x, NO_x, and PM_2), the intensive use of primary resources, contamination of wastewater, and significant amounts of hazardous and solid waste. In this context, the purpose of the current study is to perform a life cycle analysis (LCA) of four different types of steel used in the manufacturing of a steel-based radiator, namely: standard steel as a baseline scenario, steel with a recycling fraction of 40 % of scrap, steel with a recycling fraction of 60 % of scrap, fully recycled steel from scraps, and a hypothetical 'Carbon-free' steel production process. The baseline scenario relies on data from an existing company producing steel radiators. The LCA study is conducted within *SimaPro 9.4* software with data obtained from the *Ecoinvent 3.8* database and adjusted according to the defined scenarios and the functional unit of '1 kg of steel'. The environmental impact is assessed according to EN 15804 requirements for construction product sustainability. The results have shown that standard steel has the highest impact (176.87 µPt), followed by 40 % scrap steel (137.46 µPt), 60 % scrap steel (104.36 µPt), 'carbon-free' steel (76.14 µPt), and 100 % scrap steel (38.17 µPt). The climate change indicator is found to be one of the most sensitive for steel production. The selection of 'carbon-free' or 100 % scrap steel permits a decrease of impacts by 70 % and 84 %, respectively. The study concludes that the choice of steel is a fundamental point in reducing the environmental impact of construction products such as steel-made radiators within the whole life cycle perspective. Furthermore, the results obtained through the EN 15804 method, tailored explicitly for the Environmental Product Declaration (EPD), can be reused or taken as a starting point for further studies in the environmental labelling sector.

Keywords – Eco-design; LCA; resource use; steel



Different eco-design scenarios considered in the study.

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IMPACT OF ELECTRIC VEHICLE CHARGING INFRASTRUCTURE ON THE ELECTRIC LOAD PROFILE OF POWER SYSTEM: THE CASE OF LATVIA

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Abstract – The number of electric vehicles (EVs) is increasing rapidly, and charging infrastructure must keep up with that pace. With increasing charging load, a power system must adapt to the increasing power demand. The research question of this study is: what impact of EV charging on electric load profile is depending on the number of EVs and the mix of charging units (slow, medium, fast)? How much of the total power demand of EVs can be supplied from renewables, i.e., wind and solar power, considering the installed capacities of these technologies, and the match between power production and consumption. Energy system modeling on an hourly basis for different scenarios of the mix of charging units, number of EVs, and installed capacities of wind power plants and solar PVs was used as the method. EnergyPLAN software was used as the modeling tool. The results show the total power demand, peak load, and share of EV charging power demand that can be covered by renewable power technologies for Latvia's power system in the year 2050. The results are obtained for scenarios of different combinations of EV charging units.

Keywords – Electric vehicles; EnergyPLAN; mobility; renewable energy; solar PV; transport; wind power

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KxKALI v0.1: A WORK-IN-PROGRESS TOOL FOR STREAMLINING THERMAL COMFORT EVALUATION IN BUILDING DESIGN AND OCCUPANCY

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Abstract – Thermal comfort evaluation is crucial in the design of buildings, as it impacts the well-being and productivity of building occupants. Many national regulations and international standards provide guidelines for assessing thermal comfort. In order to simplify this process, we have developed a program called KxKali, which is intended to evaluate thermal comfort based on temperature and relative humidity data input using the adaptative comfort model of EN 16798. The current version of the software, v0.1, is only able to accept data from computer simulation using the official Spanish simulation software HULC and performs graphing and counting automatically, without the need for the user to edit, modify or handle any data manually. By using HULC as the source of input data, the tool can take advantage of the software's established reputation and acceptance among professionals in the building design industry in Spain, streamlining the comfort evaluation process by eliminating the need to generate input data manually, or using additional software. However, future versions are planned to accept data from other software and also monitored data. In addition, there are plans to implement the evaluation of thermal comfort following other regulations. The ultimate goal of this project is to convert KxKali into a user-friendly and widely accessible web-app that professionals can use in the design phase without performing any additional work apart from what they are already doing for energetic certification, which may improve building design by allowing architects and engineers to quickly evaluate different thermal comfort scenarios and optimize their design for comfort, and also facilitate the process of post-occupancy evaluations (POE). The goal of this presentation is to show the current capabilities of the KxKali tool, and to obtain feedback from other specialists on how to improve it and make it more widely useful. In the paper, the limitations of using simulation data from HULC and the ongoing developments of KxKali such as accepting monitoring data and converting it into a web-app will be discussed. Additionally, the paper will showcase mockups of the future web-app version of the tool, providing a glimpse into its intended user interface, and the expected reporting and output.

Keywords – nZEB; overheating; post-occupancy evaluation (POE); prevention through design (PtD); thermal comfort; thermal simulation

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LCA SENSITIVITY ANALYSIS OF AN ENERGY-BIOCHAR CHAIN FROM AN ITALIAN GASIFICATION PLANT: ENVIRONMENTAL TRADE-OFFS ASSESSMENT

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Abstract – Due to its potential applications in bioenergy production, coproducts (bio-oil and syngas), mitigation of global warming, sustainable agriculture, pollutant removal, and other uses, biochar has drawn interest from all over the world. Producing and using soil-based biochar as a method of carbon sequestration could help reduce emissions while benefiting the soil and opening up possibilities for bioenergy production. However, to characterize the production cycle's environmental and energy loads and confirm all of the advantages of biochar, Life Cycle Assessment (LCA) represents a reliable tool for evaluation. This work is based on continuing the study of Marzeddu and Cappelli (Marzeddu, Cappelli, et al., 2021) to understand the environmental impact of an energy-biochar chain involving a gasification plant in Italy. In the LCA carried out in the previous paper for the characterization of biochar, which is used as a soil conditioner, soil carbon sequestration, nitrous oxide emissions, fertilizer use, and water use for irrigation were considered. The results showed that the use of gasification for energy and biochar is an attractive strategy for mitigating the environmental impact analysis, especially climate change, with a net decrease of about $-8.3 \cdot 10^3$ kg $CO_{2,\,eq}$. The previous study was lacking a sensitivity analysis. For this reason, a sensitivity analysis is proposed in this study to consistently assess the environmental trade-offs of the biochar and the amended soil. In specific for the upstream processes the sensitivity is addressed to the selection of a different type of woodchips, for the core process in terms of selection of different packing material, and to the entire cradle-to-grave perspective by improving the logistics of the transportation, the distances within the supply chain and the choice of BAT technology for the transportation vehicles. This study highlights strategic research developments that combine to find potential environmental trade-offs and thresholds towards using biochar and its final use as a soil conditioner.

Keywords – Agricultural land detection; biochar; environmental impacts; environmental trade-offs; gasification; natural resources management; pyrolysis; sensitivity analysis

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LIFE CYCLE ASSESSMENT OF AN INDUSTRIAL LAUNDRY: A CASE STUDY IN THE ITALIAN CONTEXT

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Abstract – The high volumes of wastewater from industrial laundry with known toxicological concerns represent a relevant source of pollution for water bodies. Moreover, the unavailability of a detailed and specific Life Cycle Inventory (LCI) referring to the use of detergent within the laundry system could undermine the overall quality of the environmental assessment. This is related to the use of a substitutional product or proxy dataset for specific processes like the use of detergents. Laundry services are also known as highly energy consuming sites. This paper thus aims to make a Life Cycle Inventory (LCI) and Assessment (LCA) for an industrial laundry to provide the environmental profile for an Italian case study. The primary data input to finalize the LCI came from data collected directly from an Italian industrial laundry, integrated with literature, data provided from supporting databases (i.e. *Ecoinvent 3.8*), and data specifically obtained from the technical datasheets of detergents. The industrial laundry system considers the product's overall supply chain: extraction and manufacturing of raw materials, including the detergent, transportation and logistics, the industrial process associated with the laundry activity, wastewater treatment, recirculation packaging, and final disposal stages. The calculated environmental profiles refer to the functional unit of 1 kg of linen washed by a standard washing cycle. The system boundaries of this study include the production stages of the process. The analysed activities are the transportation for the delivery and collection of linen, the purchase of raw materials, and the sanitization and washing processes. *SimaPro 9.2* software and the *ReCiPe 2016 H* method are used for the LCA study. The baseline scenario has been compared with an alternative scenario introducing renewable energy technology (i.e. solar PV panel). The result shows a total impact of 12.77 mPt. The most impacting activities are the washing phase (4.62 mPt), the ironing phase (4.29 mPt), and the drying phase (1.56 mPt). The greatest impact in the washing phase is caused by the use of detergents and washing products. It is observed that most of the impacts fall into the categories of 'Global Warming, Human Health', 'Fine Particulate Formation', 'Carcinogenic Human Toxicity', 'Non-Carcinogenic Human Toxicity', 'Fossil Resource Scarcity'. The midpoint category with the highest impact is 'Fine Particulate Formation' with a value of 5.18 mPt. The alternative scenario introducing renewable energy technology (i.e. solar PV panel) reduces the impact by 19.7 %. Sensitivity analyses have been performed to evaluate the LCA model's uncertainty, with specific reference to the washing agents, the transportation of raw materials, and the energy consumption.

Keywords – Energy; industrial laundry; LCA; water

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MODELLING THE ELECTRIC BUS CHARGING NETWORK REQUIREMENTS FOR HVAC PURPOSES

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Abstract – Wider use of electric buses is hindered by necessity to provide cabin heating for the passengers during winter months, which in cold climates uses up as much energy as driving, thus significantly reducing bus driving range and requiring larger traction batteries, which are expensive. When the lifetime operational costs are included, unless they are heavily subsidized, the battery electric buses have troubles competing with internal combustion engine (ICE) buses in cold weather conditions. For typical ICE buses, the power capacity for heaters is in the range of 50 kW. It would be possible to increase the driving range by using heat accumulators to provide energy for vehicle thermal requirements. These heat accumulators could be recharged in bus stops using wireless charging to minimize battery size. This article describes the results of a mathematical model developed to determine optimum wireless charging power requirements for heat accumulators. The model is created for public transportation system in Riga city based on weather data in years 2017–2022 to provide passenger thermal comfort. The model simulates energy flows for bus movement and heating purposes using worst-case scenario approach. The model analysed 198 916 bus stop data, which were pertinent for weekday travels in Riga city. The analysis covered 1716 individual bus stops and 448 routes. The results showed that the charging availability during the day varied from 3 % to 55 % and on average the total energy needed for heating would be 75.6 kWh. However, in the worst-case scenario, the number rises to 237 kWh making the system too expensive for practical applications. During the research there is a very limited availability of research regarding bus heating requirements. Most of the research on thermal comfort in busses are done in hot climate and consequently mostly concerns air conditioning. The thermal comfort research about cold weather is predominantly about buildings and indoor comfort and could not directly apply, as clothing should be considered. Also, the research shows that the temperatures for comfort are lower for short haul vehicles than for the long-haul ones. All these factors strongly indicate that current conventions on temperature requirements for buses are outdated and coming from ICE buses where the heat came from the engine and was free. Therefore, the next studies should include field research analysing passenger thermal comfort levels in buses in winter to explore if there are additional opportunities for energy savings in bus HVAC systems.

Keywords – Electric bus; electric minibus; heat accumulators; HVAC; wireless power transfer (WPT); thermal comfort

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NUMERICAL EVALUATION OF WIND SPEED INFLUENCE ON ACCIDENT TOXIC SPILL CONSEQUENCES SCALES

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Abstract – This study aims to evaluate numerically the influence of wind speed on scales of environmental harmful consequences caused by accidentally spilled toxic liquid evaporated from the surface of a free-form outlined spill spot. A coupled problem of the gas-dynamic movement of a toxic air-mixture cloud in the surface layer of the atmosphere under the influence of wind and a negative toxic inhalation impact on a human in an accident zone is solved by means of mathematical modelling and computer experiment. Physical processes of toxic liquid evaporation from the spill spot, formation of a mixture of toxic gas with the incoming air, and further dispersion of a hazardous gaseous chemical in the atmosphere under various wind speed conditions are investigated. A three-dimensional non-stationary mathematical model of the turbulent movement of a gas-air mixture is used for obtaining distribution of relative mass concentration of toxic gas impurities in time and space. The model takes into account the complex terrain, compressibility of the gas flow, three-dimensional and non-stationary nature of actual physical processes, different toxic properties of chemical substances, and arbitrary contour shape of the toxic spill spot. A probabilistic harmful impact model based on using a modernized probit analysis method is used to obtain fields of the conditional probability of a fatal human injury resulting from toxic gas inhalation. This model extracts relative mass concentration of toxic gas that could cause negative impact on humans at any control point during calculation time step exposition, collects integral toxic dose values from the multicomponent gas mixture dynamics model, calculates a value of the probit function for the corresponding toxic inhalation dose dangerous factor, and automatically assesses the human fatal injury conditional probability using partial cubic Hermitian spline. This technique allows environmental safety experts assessing the scale of considered type technogenic accident consequences numerically depending on wind speed conditions and elaborating the means to mitigate them to acceptable levels.

Keywords – Accidental toxic spill; evaporation rate; gas-air mixture flow; hazardous area; inhalation toxic dose; lethal probability; mass concentration; numerical methods for solving partial differential equations; probit function; time of exposure; toxic gas

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OFF-SHORE AND *ON-SHORE* MACROALGAE CULTIVATION AND WILD HARVESTING: AN LCA-BASED EVALUATION FROM BALTIC CASE STUDIES

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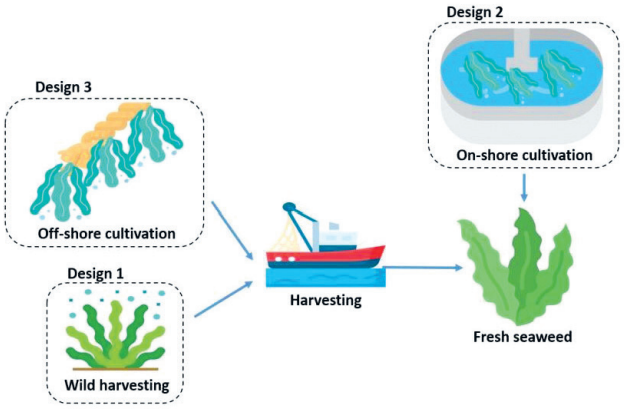
Abstract – Seaweeds are organisms with unique characteristics. They contain a broad spectrum of micro and macro elements (i.e., minerals, carbohydrates, proteins, lipids, pigments, and vitamins). Furthermore, they have a very high growth rate and are present in large quantities and species in nature. Therefore, they represent an ideal feedstock for a biorefinery concept. Historically, macroalgae used in biorefineries have been harvested directly from the sea or the shores (*off-shore* technique). However, recent studies are analysing the possibility of creating *on-shore* cultivation facilities. This research aims to perform a Life Cycle Assessment (LCA) study that analyses and compares the environmental impact of two seaweed cultivation and wild harvesting techniques in the Baltic conditions based on existing pre-commercial and commercial projects. Inventory data are collected directly from two macroalgae producers in the Baltic Sea region (one wild harvester and one *on-shore*), integrated with literature, and then normalized to the selected functional unit, i.e., 1 ton of harvested fresh macroalgae. The results, implemented with *SimaPro 9.4* software, determine which of the two techniques has the highest environmental impact and which are the most sensitive environmental indicators. Furthermore, the results underline the critical parameters for the two cultivations (i.e., fuel consumption and electricity), contributing to identifying environmental benchmarks for further optimization strategies. The alternative scenarios analysis included in the study aims to explore and highlight the effect of the variation of selected input parameters or assumptions to provide a consistent assessment of the uncertainty of the model outputs and the main findings in terms of environmental impacts.

Keywords – Baltic region; LCA; seaweed; sustainability



Different scenarios considered in the study.

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OPTICAL MODELLING OF A FRESNEL MIRROR FIELD FOR THE DEVELOPMENT OF A SPECTRAL SPLITTING CPVT COLLECTOR

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Abstract – Concentrating photovoltaic thermal (CPVT) collectors could contribute to supply renewable mid-temperature heat and electricity simultaneously, e.g. for applications in the industrial sector. Although CPVT can be still seen as a niche technology, it has a high potential for the future. One of the technological challenges of CPVT are the contradictory temperature requirements within the receiver, as the thermal part should provide temperatures as high as possible, while the electrical part consisting of conventional PV cells shows best efficiency at low temperature. Therefore, this research work focuses on the development of a CPVT collector with integrated Spectral Splitting, which is an approach to overcome the discrepancy of internal temperature demands. The basis for the developed CPVT collector is a Fresnel mirror field consisting of 28 mirror stripes and providing a gross area of 13.34 m^2. The presented paper describes the optical modelling of this Fresnel mirror field, which was necessary before working on the receiver design in order to yield the dimensions of expected focus image on the receiver input plane. Furthermore, the resulting concentrated irradiance is a major parameter for calculating thermal and electrical efficiencies of the system, thus, this was another target for the modelling work. The optical model for the Fresnel mirror field was developed in MATLAB™ in a general way, as the number of mirrors and all geometric parameters are set as input variables. This makes it possible to use it not only for the available mirror field, but also for the design and optimisation of any other Fresnel mirror system. The model calculates the single mirror angles depending on the sun position and considers all four mechanisms of internal shading that are typical for such concentrators. Furthermore, the cosine losses in transversal and longitudinal direction are calculated. The results of the modelling are satisfying, as the experimental validation on the present mirror field was successful. The model provides comprehensive outcomes like the geometric efficiency depending on the sun´s elevation angle, the mean geometric efficiency at varying geometric parameters, local and mean irradiance in the receiver input plane, as well as mean irradiance and total solar input depending on time.

Keywords – Beam splitting; hybrid solar collector; industrial heat; renewable heat and power

Acknowledgement

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OPTIMIZATION OF THE PERFORMANCE OF A CROSS-FLOW GAS MIXER FOR A PARTIAL OXIDATION REACTOR THROUGH NUMERICAL MODELLING

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Abstract – Efficient mixing of gases has many different applications in science and engineering. Gas mixers are often used in chemical reactors that use pre-mixed gases in their reaction process. In this work, we vary the geometry of a mixer in order to maximize the uniformity of the mixed gases. The mixing happens in several pipes that have small cross-flow inlets on the sides that stimulate turbulent mixing. The mixer geometry is varied by changing the configuration of the small cross-flow inlets on the pipes, and the mixing quality is quantified by the distribution of gases at certain distances from the cross-flow inlets. The flow was modelled by using open-source finite volume code. We show that standard RANS k-ϵ steady state numeric models greatly overestimate the mixing rate between different gasses, as it ignores transient changes in the flow. Transient simulations using a LES turbulence model show that the gas concentrations in the mixing pipe exhibit a pulsating behavior. The amount and the configuration of the cross-flow inlets play a significant role in how the gases mix and how the concentrations vary over time. The resulting mixer geometry will be used as a part of a partial oxidation reactor design in the future.

Keywords – Computational fluid dynamics; gas mixing; partial oxidization; shape optimization; syngas production

Acknowledgement

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THE IMPACT OF A PERMEATION GROUTING TECHNIQUE QUANTITATIVELY ASSESSED THROUGH A PROCESS-FOCUSED LIFE CYCLE ASSESSMENT

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Abstract – Permeation grouting technique can nowadays be considered a well-established ground improvement strategy in urban built environments, where an accurate fine-tuning of its component can lead to tailored and efficient interventions. But how environmentally impacting is it? Using life cycle assessment analyses (LCA) and focusing on the construction phase, this research highlights the leverages that can improve the environmental performance of this geotechnical construction process. The alternative approaches in terms of materials and processes are identified, quantified and compared using the standard output of the LCA analysis and represent the ideal input for the three-step sustainability assessment method for geotechnical infrastructure developed by the authors.

Keywords – Geotechnics; LCA; permeation grouting technique; transport infrastructure; sustainability

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TO BURN OR NOT TO BURN. LITERATURE REVIEW

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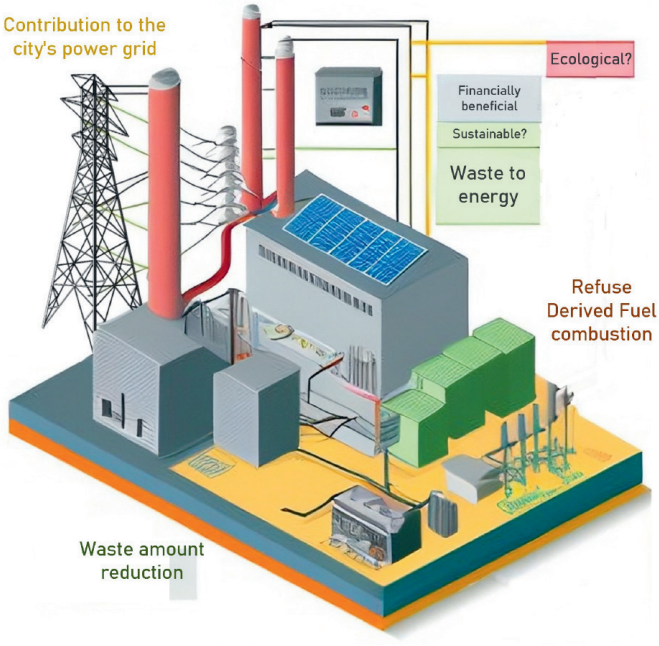
Abstract – The amount of potentially recyclable municipal solid waste in the world is growing every year. At the same time, the demand for energy is increasing globally. Waste-to-energy (WTE) technology has been proposed as a potential solution to this problem, whereby waste is burned to produce electricity. Although promoted as an environmentally sustainable solution, doubts persist regarding its actual eco-friendliness. This article analyses the literature and discusses the advantages and disadvantages of WTE technology in Latvia and at the general level. The focus of this article is the potential advantages of WTE technology, which encompass a decrease in landfill waste, retrieval of valuable resources, production of energy, and improving financial feasibility. Disadvantages, such as a potential increase of emissions, loss of valuable materials, breaking development of recovery technologies and practices, and neglection of circular economy plans, are also discussed.

Keywords – CO_2; refuse derived fuel; RDF; waste; waste-to-energy; WTE



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TRNSYS SIMULATION OF THE USE OF SOLAR COLLECTOR-BASED DOMESTIC HOT WATER SYSTEM IN CENTRAL AND EASTERN EUROPEAN COUNTRIES (CEEC)

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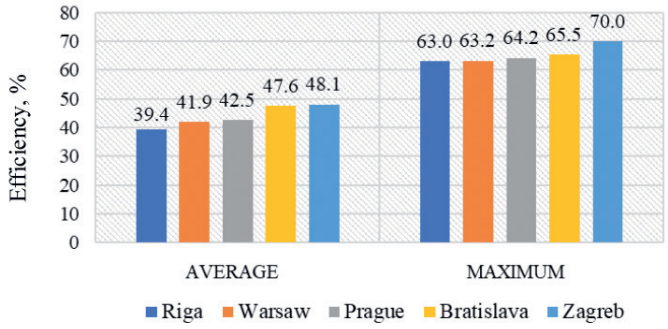
Abstract – With the prevailing energy crisis and the public's growing environmental awareness, renewable energy sources (sun, wind, water) are playing an increasingly important role in Europe and around the world. Due to its easy availability and relatively high efficiency, it is the solar energy that is attributed with great potential in decarbonizing the energy sector. Among the most popular devices that enable the use of solar radiation are solar collectors. They are used in heating and domestic hot water preparation systems, as well as for heating swimming pool water. However, their efficiency depends on many factors, of which the main one being the climatic conditions. This paper presents the results of energy simulations of a solar collector-based domestic hot water system for the capitals of five selected Central and Eastern European Countries (CEEC) – Riga (Latvia), Warsaw (Poland), Prague (the Czech Republic), Bratislava (Slovakia), and Zagreb (Croatia). The system model was developed using the TRNSYS software, in which dynamic simulations were also performed for an entire year (8760 h). For each location, the efficiency of the flat-plate solar collectors, the amount of useful energy generated by them, as well as the amount of energy needed to meet the load and auxiliary energy requirements were analyzed and compared. The extent to which increasing or decreasing the area of solar collectors affects the operation and efficiency of the system for different locations was also estimated. The results showed that in terms of efficiency, the use of solar collectors is most favorable in Slovakia and placed southernmost-located Croatia, where it also achieved the lowest annual auxiliary energy demand. The least favorable location, on the other hand, turned out to be the capital of Latvia. It is also worth noting that regardless of location, the area of solar collectors has a significant impact on the efficiency of the entire system.

Keywords – Domestic hot water; renewable energy; simulation; solar collectors; trnsys



Annual results of average daily efficiency of solar collector.

Acknowledgement

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USE OF SYNTHETIC FUELS DERIVED FROM GREEN HYDROGEN AND CO_2 IN HEAVY-DUTY AND LONG-RANGE TRANSPORT: THE CASE OF LATVIA

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Abstract – Decarbonization of the transport sector may be more challenging than it is for the power supply and heating sectors. Green hydrogen, i.e., produced from renewable energy sources, combined with CO_2 captured from flue gases or air can be used to produce synthetic fuels, e.g., dimethyl ether (DME), ammonia, and jet fuel. These synthetic fuels can be used in heavy-duty and long-range transport, i.e., trucks, ships, and airplanes. The research question of this study is: how much green hydrogen and CO_2 is needed to replace fossil fuel in the mentioned transport sectors with synthetic fuels? How much of the power demand for production of the synthetic fuels can be supplied from renewables, i.e., wind and solar power, considering the installed capacities of these technologies, and the excess power that can be used for the hydrolysis process. The case of Latvia for the year 2050 is used for the simulation of scenarios with various mixes of renewable power production. The simulation is done on an hourly basis for the whole year, using EnergyPLAN software as the modeling tool. The results show the total hydrogen and CO_2 demand, the total power demand for hydrolysis of green hydrogen, and the share of the demand that can be covered by renewable power technologies. The results also include the costs of synthetic fuel supply for the considered transport sector. The results are obtained for scenarios of different combinations of installed capacities of wind power plants and solar PVs.

Keywords – EnergyPLAN; hydrolysis, mobility; renewable energy; solar PV; transport; wind power

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BIOTECHNOLOGIES, BIORESOURCES

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ACCELERATING MICROORGANISM STRAIN SELECTION FOR ENHANCED PRODUCTIVITY: A REVIEW OF MICRODROPLET TECHNOLOGY SOLUTIONS FOR SCREENING MUTANT AND GMO STRAINS

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Abstract – This article reviews state-of-the-art microdroplet technological solutions for screening microorganisms mutant and GMO strains. Microorganisms used in the production of various products – single-cell protein, single-cell oil, enzymes, pigments and other bioactive compounds – can always be improved and their properties enhanced to increase the production of products of interest, to simplify microbial cultivation process, improve efficiency or adapted strains to use cheaper raw materials such as agroindustrial by-products. Microorganisms can be improved using either classical mutagenesis techniques or genetic engineering methods. Regardless of the selected method for mutant or GMO creation, during the process most promising microorganism strains must be selected, which is usually a slow and labour-intensive process. The use of microdroplets is a promising technological solution to speed up strain selection. This review looks at the latest developments in microdroplet technology, compares their variations, and identifies future prospects.

Keywords – Biotechnology; genetic engineering; GMO strains; industrial microbiology; microdroplet technology; microorganisms; mutant strains; screening; strain selection

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ADVANCING HONEY BEE BREEDING WITH LOW-COST, RAPID AND ACCESSIBLE DNA ANALYSIS TECHNIQUES

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Abstract – Colony collapse disorder (CCD) is a major concern for beekeeping, and consistent breeding efforts are essential in addressing the various factors that contribute to CCD. Traditional breeding methods are often labour-intensive and may not yield the desired results in improving bee colony characteristics. The DNA analysis offers a potential solution by enabling the acceleration of breeding efforts, increasing predictability and reducing workload. While honey bee DNA analysis has been available for some time, its use in bee breeding has been limited to a few companies and research institutions. This review article aims to expand access to the DNA analysis by summarizing the genetic characteristics that can be determined, methods for predicting the transmission of these characteristics to future generations, and reviewing the most widely available methods and service providers for conducting DNA analyses. By utilizing the DNA analysis, a wider community of bee breeders can effectively address CCD and improve the quality and health of bee colonies.

Keywords – Accessible technology; colony collapse disorder (CCD); DNA analysis; honey bee breeding; genetic characteristics; low-cost methods; predictive breeding

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ADVANCING HONEY BEE BREEDING: A REVIEW OF THE MOST EFFECTIVE METHODS FOR INTRODUCING NEW QUEEN BEES

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Abstract – The aim of this review article is to identify the most commonly used methods for introducing new queen bees to a colony and to evaluate their success rates. Through a literature review, the authors select the most frequently used methods and assess their advantages and disadvantages, as well as the success rate for each method. While beekeepers have developed various methods for introducing new queen bees, there have been no comprehensive studies to determine which methods have the highest success rates. Successful introduction of a new queen bee is crucial for beekeeping, as unsuccessful introductions can result in the loss of queen bee material, colony collapse, development of laying worker bees and reduced productivity of the colony.

Keywords – Beekeeping; laying worker bees; queen bee introduction methods; queen honey bee rearing; queen bee productivity; queen bee replacement; queen bee success rate; queen rearing

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OPTIMIZING BIOBUTANOL PRODUCTION FROM AGROINDUSTRIAL BY-PRODUCTS: A MULTI-CRITERIA ANALYSIS APPROACH TOWARDS A CIRCULAR ECONOMY

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Abstract – Biobutanol is a more efficient alternative to petrol than bioethanol and can be used as a partial or complete substitute for petrol in unmodified internal combustion engines. Sustainable production of the biobutanol depends on the used feedstock source and its pretreatment methods, selected enhancing strategy of microorganism strain, acetonebutanolethanol fermentation effectiveness, and solvent recovery techniques. The aim of this paper is to find the most optimal set of technological solutions for the production of biobutanol from agroindustrial by-products for cost effective manner in line with circular economy principles. Identification of the optimal solution set for efficient biobutanol production for agroindustrial by-products will be done by using multi-criteria analysis (MCA). This paper provides MCA results and methodology description.

Keywords – Acetone-butanol-ethanol (ABE) fermentation; agroindustrial byproducts; biobutanol; biofuels; circular economy; feedstock source; multi-criteria analysis (MCA); petrol alternative; solvent recovery techniques

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OPTIMIZING BIOBUTANOL PRODUCTION: ANALYSIS OF FEEDSTOCK SELECTION, PRE-TREATMENT METHODS, AND MICROORGANISM STRAINS FOR BIOBUTANOL PRODUCTION FROM AGRICULTURAL AND INDUSTRIAL BY-PRODUCTS

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Abstract – This study presents an analysis of key elements of biobutanol production, including feedstock selection, pre-treatment methods, and microorganism strains. Using laboratory experiments, we evaluated the ability of different microorganisms to convert various agricultural and industrial by-products into biobutanol. We tested three microorganism strains: *C. acetobutylicum* DSM 792, *C. beijerinckii* DSM 6423, and *C. saccharoperbutylacetonicum* DSM 14923. The results showed that biodiesel production residues, various agricultural hydrolysates, yeast residues, and milk processing residues were the most suitable feedstocks for biobutanol production. In addition, the authors explored different pre-treatment methods, such as microbial and chemical hydrolysis, to enhance the efficiency of biobutanol production. Our findings provide valuable insights for optimizing biobutanol production processes in line with sustainable and cost-effective production principles.

Keywords – Acetone-butanol-ethanol (ABE) fermentation; agricultural by-products; biobutanol; bioprocess optimization; chemical hydrolysis; feedstock, industrial by-products; microbial hydrolysis; pretreatment methods

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OPTIMIZING HONEY BEE DRONE REARING: AN EXAMINATION OF COLONY MANAGEMENT TECHNIQUES AND THEIR IMPACT ON SPERM QUALITY

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Abstract – The vitality, ejaculation success, sperm quantity, sperm viability and motility directly depends on the breeding conditions of the honey bee drones because since the egg stage, both the larva and the adult drones are fully taken care of by the worker bees. Worker bees choose to care for and feed drone brood only during the season when mating of virgin queen bees takes place in nature. If there is a lack of food resources in the bee colony, the worker bees can decide not to feed both the drone larvae and adult drones and throw them out of the nest. In this field study, the various methods of preparation of drone rearing colonies are reviewed and tested: in the presence of a queen and without one, with an additional feed base (sugar syrup, honey, pollen), various sizes of colonies, etc. Drones were reared in these colonies, then their sperm were collected and sperm motility, viability, cell concentration and sperm quantity per drone were determined. In addition to that, authors also evaluated the parameters characterizing the quality of sperm in different races of honey bee drones.

Keywords – Beekeeping; colony management; drone rearing; honey bee drone semen; sperm cell concentration; sperm motility; sperm viability

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ALGAL BIOTECHNOLOGY: PROPERTIES OF BIOACTIVE DERIVATIVES AND PHARMACEUTICAL APPLICATIONS

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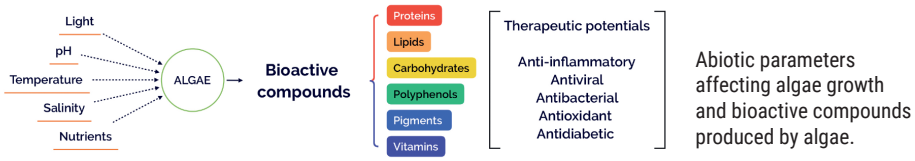
Abstract – Continuous development of new pathologies and mutations together with the increment of drug resistance make the research of new treatments and therapies more urgent and essential. Among the renewable resources, algae and related bioactive compounds are strongly considered. Algae are eukaryotic organisms characterised by high therapeutic potential. Indeed, because of biotic and abiotic factors, algae produce a wide variety of metabolites, which are useful for treating dysfunctions and diseases. The most produced metabolites are proteins, carbohydrates, lipids, vitamins, polyphenols, and pigments, which find several applications in daily life, as indicated in Fig. 1. The different classes of metabolites are relevant to the species they belong to; they are also divided into groups according to their medical properties. Over the years, advantages and performances of algae derivatives have been demonstrated by a growing number of analyses and researches, especially in recent years. Among the various properties of algae metabolites, anti-inflammatory, antiviral, antibacterial, antioxidant and antidiabetic are the most promising. Pigments (e.g. fucoxanthin) and polyphenols are the main compounds with anti-inflammatory activity; the latter also show antiviral, antidiabetic and antibacterial effects. Other compounds with antidiabetic activity are some xanthophylls and some polysaccharides (e.g. fucoidan and alginate). Among the antioxidant metabolites of algae, the most useful are flavonoids (i.e. polyphenols), carotenoids, pigments, vitamins, minerals and enzymes. Fatty acids show antibacterial ability, while carrageenans and other polysaccharides show both antibacterial and antiviral effects. Supporting algal research is a valid strategy to improve ongoing trials, expand or confirm obtained results, discover and include new molecules in biotechnology applications with the aim to introduce novel medical and pharmacological uses in modern medicine. A typical example is related to diabetes mellitus, which is a disease in constant growth. Nowadays, numerous trials are ongoing to develop innovative and more efficient treatments and several algae are analysed with respect to this pathology. Indeed, some algal bioactive compounds, in particular polyphenol derivatives, polysaccharides and pigments, have antidiabetic properties; these metabolites inhibit the enzymes α-glucosidase, α-amylase and aldose reductase, reduce reactive oxygen species, decrease lipid peroxidation and interfere on metabolic pathways. The results are decrement of blood glucose levels and increment of insulin values, which are critical in diabetic patients.

Keywords – Algae; algal growth; biomass; bioproducts; metabolites; therapeutic potential



Abiotic parameters affecting algae growth and bioactive compounds produced by algae.

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BIOBUTANOL PRODUCTION FROM AGRO-INDUSTRIAL BY-PRODUCTS USING ABE FERMENTATION: ANALYSIS OF FEEDSTOCK EFFECT ON BIOBUTANOL YIELD AND TITER

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Abstract – This study examined a range of agro-industrial by-products that could be used as potential carbon and nitrogen sources for ABE fermentation. In general, the study examined more than a dozen different by-products from dairy, biodiesel, sugar, agriculture, beverage, food, etc. production industries. The by-products were tested to determine which of them would result in higher biobutanol yield and concentration in the fermentation medium. All by-products were used in the cultivation of three bacteria of the genus *Clostridium* to observe differences also between the strains' ability to utilize the respective substrates. The test results demonstrated that the most suitable by-products for ABE fermentation, which served as carbon sources, are biodiesel and sugar production by-products and hydrolysates of agricultural residues. These by-products are available in large quantities. The tests show that they serve as a good energy source for the production of butanol fuel. By-products of dairy processing and specific beverage production residues (yeast residues) showed the best results as the most suitable nitrogen sources; however, these by-products are either limited in availability at scale or their transportation is uncompetitive due to the high water content. This study shows that ABE fermentation can be provided with a range of different agroindustrial by-products. The wider use of these by-products in the future can reduce the negative impact on the environment, reduce the production costs of ABE fermentation products and allow obtaining an efficient biofuel – biobutanol, which can compete with bioethanol and biodiesel.

Keywords – Acetone-Butanol-Ethanol (ABE) fermentation; agricultural by-products; bioprocess optimization; butanol; feedstock; industrial by-products

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COMPILATION OF GROUPS OF MUTAGENS USED TO OBTAIN OPTIMIZED YEAST STRAINS

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Abstract – Yeasts can be used to process industrial by-products to produce products with higher added value. To optimize the technology, new yeast strains can be created through mutagenesis with improved traits of interests. To achieve this, different mutagens can be used. Mutagens can be divided into physical, chemical, and biological. Each type has its own methodology, operating mechanisms, advantages, and disadvantages. Physical mutagens are the oldest, of which UV radiation is the most used. However, others are less commonly used for yeast mutagenesis due to complicated or unwieldy instrumentation. Chemical mutagens are the most widely used to obtain improved yeast strains. The most recent mutagens to be used under laboratory conditions are biological mutagens. Using the CRISPR/Cas9 system, it is also possible to create targeted changes in previously selected regions of the genome in yeast species.

Keywords – Biological mutagenesis; chemical mutagenesis; optimized yeast strain; physical mutagenesis; UV radiation; yeast

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FUNGAL HYDROLYSIS OF FOOD WASTE: REVIEW OF USED SUBSTRATES, CONDITIONS, AND MICROORGANISMS

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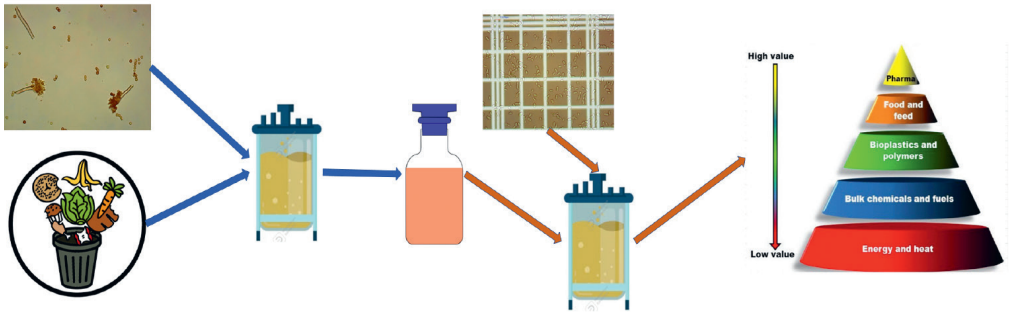
Abstract – Food production generates significant amounts of organic waste that can have negative effects on the environment, such as water, soil and air pollution, due to lack of efficient utilisation solutions and insufficient disposal practices. Fungi have great enzymeproducing abilities that can be used for hydrolysing various types of food waste. Carried out in optimal conditions, fungal hydrolysis of generated food waste can be fast and efficient. Currently, fungal hydrolysis capacity for waste treatment has only been briefly demonstrated in previous studies. This review focuses on and summarizes different practises showing the potential of fungal hydrolysis for the use in efficient resource management. The main accent was put on what organisms and waste have been used in previously conducted studies. In addition, temperature, pH level and glucose recovery yields were reviewed. It was concluded that food waste can be efficiently hydrolysed and used as substrates for downstream production of value-added products. The optimal temperature for fungal hydrolysis is above 45 °C, and optimal pH level can differ depending on the process. The possibility of fungal strain optimization and creation of the enzymeproducing mutant, as well as the use of other GRAS fungi should be investigated. To explore a wider range of waste residues, researchers must collaborate with manufacturers to conduct tests and valorise new residues for fungal hydrolysis.

Keywords – Biowaste; biological hydrolysis; by-products; enzymatic activity; fermentation; fungi; food waste; glucose recovery; microbial hydrolysis; mixed culture; waste biomass



Two step fermentation diagram.

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LIFE CYCLE ASSESSMENT OF BLACK SOLDIER FLY, YELLOW MEALWORM AND SOYBEAN PROTEIN FOR USE IN FISH FEED

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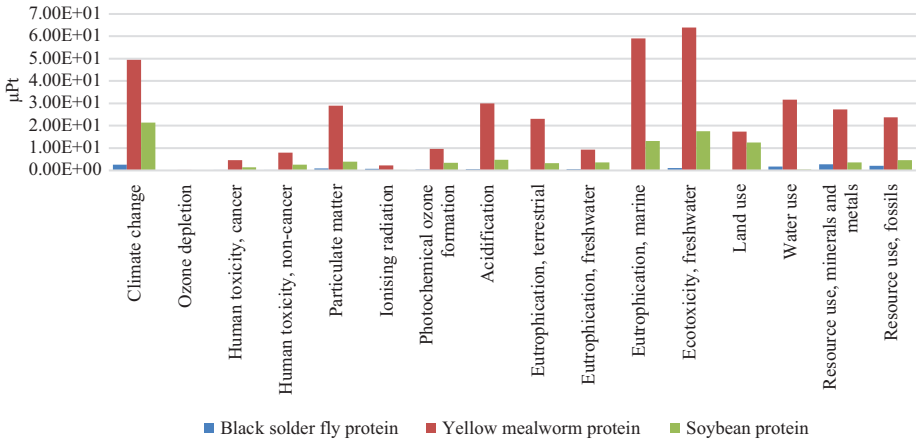
Abstract – As the consumption of fish in the human diet increases, a larger amount of production is needed. The growing demand for fish also has an impact on fish feed, its production efficiency and the sustainability of using raw materials. To evaluate the sustainability of raw materials and the impact on the environment, three protein alternatives are compared – black soldier fly, yellow mealworm and soybean. Each alternative has advantages and disadvantages. The advantages of black soldier fly and yellow mealworm are a valuable source of protein, sustainable growth (as feed can be used for food waste) and no need for arable land. Disadvantages of black soldier fly and yellow mealworm are price, an unbalanced diet can negatively affect growth, and nutritional value effect on the fish vary depending on fly or mealworm species. The advantages of soybeans are price, availability and high protein content, but the disadvantages are a lack of essential amino acids that affect the quality of fish and poor palatability. An LCA study has been carried out for the black soldier fly, yellow mealworm and soybean protein. From PEFCR most relevant impact categories are climate change, particulate matter, acidification, land use, eutrophication terrestrial and water use. The total single score value for black soldier fly protein is 1.43E+01 µPt, for yellow mealworm protein is 3.89E+02 µPt and for soybean protein is 9.72E+01 µPt. Large impact is from electricity consumption, used components for feed. Sensitivity analysis was performed for black soldier fly protein and yellow mealworm protein production, where feed composition was changed. In sensitivity analysis environmental impact is less from the new feed structure. The reason might be that the new feed structure has used food waste and wheat as feed ingredients.

Keywords – Black soldier fly; fish feed; LCA; protein sustainability; soybean; yellow mealworm



Weighted protein results for impact categories.

Acknowledgement

The research has been supported within the framework of the European Regional Development Fund project No. 1.1.1.5/17/I/002 "Integrated national level measures for strengthening interest representations for research and development of Latvia as part of European Research Area" by funding project No. 23-11.17e/21/165 "Non-Food Organic Resources-based feeds optimised for salmon until post-smolt stages" (NON-Fôr).

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MUTAGENESIS AND SELECTION STRATEGIES OF SCO AND CAROTENOID PRODUCING MICROORGANISMS

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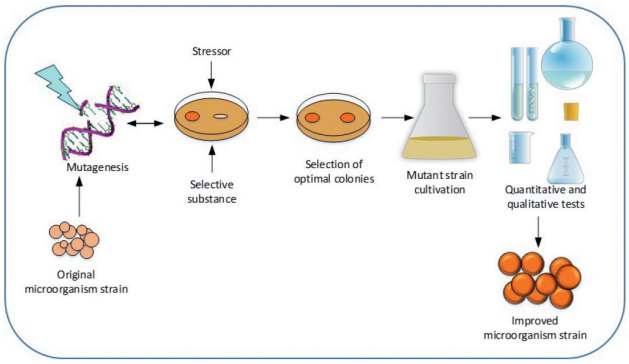
Abstract – Biotechnologies of microorganisms for producing various industrially important products, such as single-cell oil (SCO), single-cell protein (SCP), carotenoid, enzymes, etc., have been studied since the last century and are of current actuality to the present day. The SCO and carotenoids are an alternative to oil of plant and animal origin and to pigment of plant and synthetic origin, respectively. These cellular components of microorganisms can be used in the food, aquaculture and livestock feed, pharmaceutical, and cosmetic industries. However, microorganisms-based technologies have not found ubiquitous practice due to a number of limitations. One of them is the threshold of the oil and carotenoids content in the biomass of microorganisms due to their nature. Therefore, the development of the fast-growing strains with a high level of these product accumulation is required. Random mutagenesis, adaptive laboratory evolution (ALE), and genetic engineering are used for strain improvement. This paper reviews random mutagenesis as a simple, cost-effective tool for improving single-cell oil and carotenoid synthesis in microorganisms, followed by the selecting of mutants with preferable characteristics. Nevertheless, it should be considered that random mutagenesis accelerates naturally occurring nonspecific mutations by exposure to a physical or chemical mutagenic agent. Despite the result of a large variety of created mutants, the characteristics of the mutants can be unstable and reversible. Therefore, different cultivation strategies for developing traits of interest and testing their persistence are reviewed in this study. Choosing effective mutagenesis techniques, screening, and selection methods is essential for creating suitable mutant strains. Various strengths and drawbacks of such tools are discussed in this review, and the main directions for further development are highlighted.

Keywords – Antimycin A; carotenogenesis; cerulenin; diphenylamine; fatty acid inhibitors; isoniazid; mutagenesis; mutant; single-cell oil; triclosan; β-ionone



Creation of mutant strains with preferable properties.

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OPTIMIZATION OF ULTRASOUND-ASSISTED EXTRACTION CONDITIONS FOR ACTIVE ESSENTIAL OIL AND ANTI-ALZHEIMER ACTIVITIES FROM *MENTHA CORDIFOLIA*

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Abstract – *Mentha C.* (*Lamiaceae*) is distributed all over the world. Essential oils were found menthol, menthofuran, menthyl acetate, menthone, 1.8-cineole, pinene, myrcene and borneol. *Mentha C.* most popular herbs are widely used in cooking, in cosmetics, complementary therapy and pharmaceutical for anticarcinogenic, gastro protective, anti-inflammatory, antimicrobial and antivirotic purposes. For essential oil extraction, a steam distillation, or hydro-distillation method was used, which allows the decomposition of components. The aim of this work was to study the innovative technologies of essential oil by ultrasound-assisted extraction (UAE) that include high yields, short-extraction time and save energy. The extraction of essential oils was carried out at three ultrasonic frequencies (15 kHz, 20 kHz, and 25 kHz), sonicated times were 1, 2 and 3 hours. The solvents extracted were hexane, ethylacetate and 95 % ethanol. The sonication conditions were different of compounds showed by Thin Layer Chromatography (TLC). The extraction compounds by hexane from sonicated at 20 kHz (2 h) were terpene hydrocarbon which was nonpolar essential oil. The oxygenated terpenoids were extracted by ethyl acetate from sonicated at 20 kHz (3 h) and the phenolic compounds were extracted by 95 % ethanol. The data was treated by applying multivariate statistical analysis. The tested of antioxidant by DPPH, and ABTS radical were the best of ethanol extracted IC_{50} 73 mg/ml, ethyl acetate extracted and ethyl acetate extracted IC_{50} 103 mg/ml, respectively. IC_{50} of anti-acetylcholinesterase were 125.5 mg/ml of ethyl acetate extracted.

Keywords – Anti-Alzheimer; antioxidant; essential oil; Mentha Cordifolia; ultrasound-assisted

Acknowledgement

This work was generously supported by Suansunandha Rajabhat University, Bangkok, Thailand. I am grateful to Assoc. Professor Weena Jiratchariyakul Department of Pharmacognosy, Faculty of Pharmacy, Mahidol University Bangkok, Thailand, for providing chemicals and advice for this study.

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ENVIRONMENTAL IMPACT OF NATURAL AND SYNTHETIC ASTAXANTHIN PIGMENTS USING LIFE CYCLE ASSESSMENT

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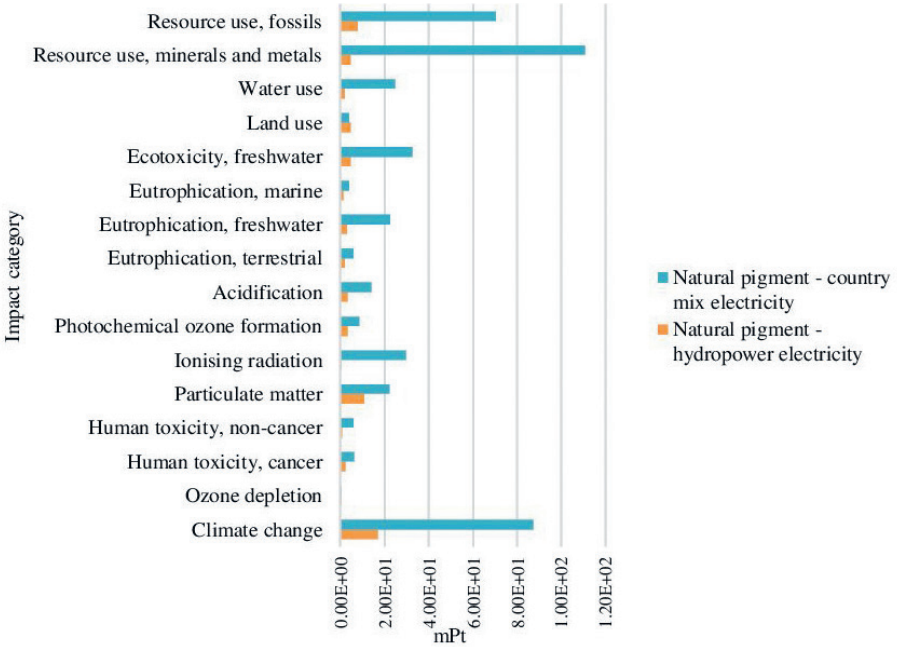
Abstract – The growing demand for fish and the development of the industry raise concerns about environmental impact. As fish production increases, so does the consumption of fish feed. One of the ingredients in fish feed is pigment, which improves the nutritional value and visual appearance of the product, increasing their marketability. Astaxanthin is a red pigment that also has high antioxidant activity. Natural pigment from microalgae or synthetic pigment may be used in feed. The advantage of natural pigment from microalgae is ecological benefits, as the microalgae culture can sequester carbon and release oxygen. The advantage of synthetic pigment is the economic aspect. The Life Cycle Assessment (LCA) method was used to determine the environmental impact of natural and synthetic pigments. The results obtained from the LCA are expressed according to the impact categories defined by the Product Environmental Footprint Category Rules (PEFCR). Sensitivity analysis was performed for natural pigment, and changes were made only to electricity – electricity is produced by hydropower in Norway, or a country mix from Norway was used. Total single score value for natural pigment is 6.85E+01 mPt, and the largest impact is from preparation of the culture medium phase – from sodium nitrate and magnesium sulfate. Sensitivity analysis results for electricity from a country mix is 4.50E+02 mPt. Total single score value for synthetic pigment is 1.07E-01 mPt. The largest impact is from methanol and electricity consumption. Synthetic pigments have a lower environmental impact than natural pigments; however, a sensitivity analysis shows that the environmental impact can be reduced by choosing an alternative to electricity. It should be noted that the comparison presented reflects a general comparison of alternatives, as the input data is derived from a literature review.

Keywords – Fish feed; LCA; pigment sustainability



Natural pigment weighted results for impact categories for hydropower electricity and country mix electricity

Acknowledgement

The research has been supported within the framework of the European Regional Development Fund project No. 1.1.1.5/17/I/002 "Integrated national level measures for strengthening interest representations for research and development of Latvia as part of European Research Area" by funding project No. 23-11.17e/21/165 "Non-Food Organic Resources-based feeds optimised for salmon until post-smolt stages" (NON-Fôr).

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PREDICTING THE FERTILITY OF LONG-TERM HONEY BEE DRONE SPERM STORAGE THROUGH CORRELATION OF *IN VITRO* AND *IN VIVO* DATA

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Abstract – The article describes a study on the long-term storage of honey bee drone sperm and the evaluation of its quality. The current method of evaluating sperm quality, which involves inseminating queens and waiting for progeny. It is time-consuming and limited by the seasonal nature of beekeeping. The study aims to find correlations between queen fertility rates and sperm quality indicators in the queen spermatheca versus sperm quality indicators after storage in a thawed sperm sample. The study also examines the correlation between number of sperm cells, sperm motility, sperm viability, proportion of worker bee broods, sperm quality indicators in the spermatheca of queen bees, and duration of queen laying. The goal of this study is to validate *in vitro-in vivo* data and to facilitate future research on sperm storage issues.

Keywords – Drone sperm fertility; honey bee drone sperm storage; in vitro-in vivo data correlation; queen fertility; spermatheca; sperm motility; sperm quality evaluation; sperm viability; worker bee brood

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SUSTAINABLE CRYOPRESERVATION AND ABOVE-FREEZING STORAGE SOLUTIONS OF EUROPEAN HONEY BEE APIS MELLIFERA DRONE SEMEN: A REVIEW

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Abstract – The European honeybee *Apis mellifera* is the main pollinator for most crops used for human consumption. However, a number of diseases, parasites, pesticides and other factors that generally result in the widely described colony collapse disorder weakens honeybee colonies. In order to maintain the existing honeybee germ lines and facilitate the creation of new disease-resistant lines, it is necessary to ensure consistent breeding work, which would also allow the long-term preservation of the unique germplasm lines. One of the most promising solutions for the preservation of honeybee germplasm is the storage of honeybee drone semen. In recent decades, there has been a renewed interest in the preservation of honeybee drone semen using both cryopreservation and non-freezing storage methods. This review will look at the latest developments in novel sperm storage technologies and compare them with well-known preservation solutions. Additionally, the most accessible and widely used solutions will be reviewed, taking into account the cost of the necessary equipment, the complexity of the methods, time consumption and resulting sperm quality.

Keywords – Honeybee drone semen; instrumental insemination; low cost laboratory setup; non-freezing semen preservation; semen cryopreservation

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REVIEW ON SUSTAINABLE CRYOPRESERVATION AND NONFREEZING STORAGE SOLUTIONS OF EUROPEAN HONEYBEE *APIS MELLIFERA* DRONE SEMEN

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Abstract – The European honeybee *Apis mellifera* is the main pollinator for most crops used for human consumption. However, a number of diseases, parasites, pesticides and other factors that generally result in the widely described colony collapse disorder weakens honeybee colonies. In order to maintain the existing honeybee germ lines and facilitate the creation of new disease-resistant lines, it is necessary to ensure consistent breeding work, which would also allow the long-term preservation of the unique germplasm lines. One of the most promising solutions for the preservation of honeybee germplasm is the storage of honeybee drone semen. In recent decades, there has been a renewed interest in the preservation of honeybee drone semen using both cryopreservation and non-freezing storage methods. This review looks at the latest developments in novel sperm storage technologies and compares them to well-known preservation solutions. Additionally, the most accessible and widely used solutions will be reviewed, taking into account the cost of the necessary equipment, the complexity of the methods, time consumption and resulting sperm quality.

Keywords – Honeybee drone semen; instrumental insemination; low cost laboratory setup; non-freezing semen preservation; semen cryopreservation

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STRATEGIES FOR THE MICROBIAL CAROTENOIDS PRODUCTION COMPETITIVENESS IMPROVEMENT

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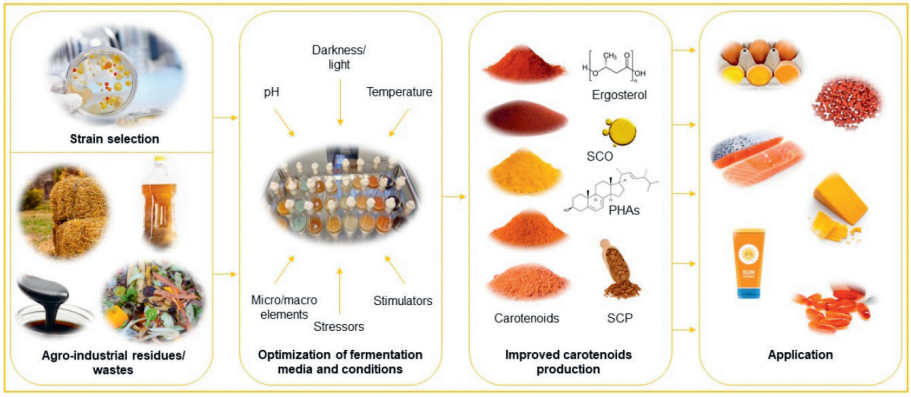
Abstract – The research and development of carotenoids production have a long history, and interest in this group of pigments has not decreased to this day. Among all existing carotenoids, six are considered industrially important: astaxanthin, β-carotene, lutein, zeaxanthin, canthaxanthin, and lycopene. These carotenoids have a wide range of application and are used as additives in food and beverage, feed, nutraceuticals, pharmaceuticals, and cosmetics due to their bioactive and colour properties. An undisputed leader in the global pigment market is chemically synthesized carotenoids. To a lesser extent, carotenoids derived from natural sources as plants and microorganisms. Currently, the market of natural carotenoids is mainly represented by microalgae *Haematococcus pluvialis*, *Dunaliella salina*, *Botryococcus braunii*, fungus *Blakeslea trispora*, yeast *Phaffia rhodozyma* and bacteria *Paracoccus carotinifaciens*. These microorganisms afford the production of astaxanthin, βcarotene, canthaxanthin, and lycopene. In turn, lutein is obtained by extracting marigold flowers *Tagetes eracta L.* and there is no other competitive source yet. Therefore, the potential of microorganisms to synthesize and accumulate lutein and other equally important carotenoids in their cells has been actively studied. Several yeast and bacteria species from Rhodosporidium, Rhodotorula, Sporobolomyces, Sphingomonas, Gordonia, and Sphingobacterium genus have a potential to replenish the diversity of sources of industrially important natural pigments, but available technologies still need improving. This paper reviews strategies for increasing of competitiveness of fungal and bacterial carotenoids production. Strategies such as selection of carotenogenic strain, use of low-cost substrates, simultaneous production of carotenoids and other value-added compounds, and optimization of fermentation medium and conditions are considered.

Keywords – Agro-industrial wastes; bacteria; by-products; ergosterol; pigment; polyhydroxyalkanoates; single-cell oil; single-cell protein; yeast



Strategies for improving microbial carotenoid production.

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SUSTAINING A MARS COLONY THROUGH INTEGRATION OF SINGLE-CELL PROTEIN AND OIL PRODUCTION IN FOOD SUPPLY CHAINS

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Abstract – As humanity sets its sights on establishing a sustainable and prosperous colony on Mars, one of the key challenges to overcome is ensuring a reliable and nutritious food supply for settlers. While various solutions for food production on Mars have been proposed, there is a growing interest in the use of microorganisms as a means of producing essential nutrients. This review article highlights the advantages of utilizing single-cell protein and single-cell oil technologies to produce essential amino acids and fatty acids for the food supply chains of a Mars colony. We provide an analysis of the potential benefits, challenges and limitations of these solutions and outline the necessary steps to be taken in order to successfully integrate them into the infrastructure of a Martian settlement.

Keywords – Biotechnology; food production; life support systems; Mars colonization; microorganisms; single-cell protein, single-cell oil; space agriculture; sustainability

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USE OF SINGLE-CELL OILS IN THE PRODUCTION OF BIO-BASED EPOXY: AN OVERVIEW OF THE MOST SUITABLE MICROORGANISMS AND OIL PROPERTIES

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Abstract – Epoxy resins are widely used polymers that are mainly synthesized from fossil feedstocks. In order to reduce the use of fossil-derived epoxies, various solutions are widely studied, such as replacing conventional raw materials with more environmentally friendly, non-toxic solutions, such as vegetable oil. One of the less studied but potentially highly competitive feedstock for the synthesis of bio-based epoxies is single-cell oils (SCO). Single-cell oils have a number of advantages over vegetable oils, such as the fatty acid profiles of SCO are more suitable for the polymerization of epoxides, the production of SCOs is faster and more environmentally friendly. Thanks to the wide range of SCO-producing microorganisms, it is possible to find the exact SCO that is suitable for the specific application of the produced epoxy. Despite the potential advantages, SCO derived from microorganisms such as yeasts, fungi and bacteria, have received very limited coverage in the scientific literature. Therefore, this review summarizes the available information on single-cell oils and evaluates their suitability for use as feedstock in epoxide synthesis. The following aspects are reviewed in this paper: microorganism strains that can be used in the production of SCO; fermentation rates and SCO yields; applicable low-cost raw materials used for the cultivation of microorganisms; the fatty acid profile of the relevant SCO and other factors that are significant for suitability evaluation of the relevant SCO. To the best of authors knowledge this is the first review paper to summarize potential SCOs for their application in synthesis of bio-based epoxides and first paper to give an overview of fungal and bacterial oils for such application.

Keywords – Bio-based epoxy; bio-based polymers; bioresource management; single cell oil; microbial oil; oleaginous microorganisms

04

RENEWABLE ENERGY TECHNOLOGIES

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BIBLIOMETRIC REVIEW OF ELECTRIFICATION OF ENTERPRISE AND LAST-MILE DELIVERY FLEET

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Abstract – The impact of transport on carbon emissions accounts for 16.2 % of total global emissions, of which road transport accounts for 11.9 %. Road freight accounts for 40 % of road transport emissions and 4.76 % of global CO_2 emissions. This study analyses the existing scientific literature in the field of transport electrification for transport companies in general and for 'last mile delivery' logistics companies specializing in urban delivery within parcel collection networks. The purpose of this study is to determine the state of the art for electric vehicles in fleets and how this topic can be assessed for sustainability. Bibliographic validation is primarily quantitative and is the most efficient method for dealing with the large volumes of information from the Web of Science (WoS) and Scopus databases. VOSviewer software was used to map the relationships between the most frequently used keywords in academic articles. The results show a small number of research papers addressing the electrification of fleet transportation. Only 1 of 523 WoS publications and 1 of 656 fleet transport publications in Scopus covered last-mile delivery for the selected period (1985–2022). It should also be noted that only 39 publications in 1987 in WoS database and 29 papers in 1891 in Scopus on transport electrification have sustainability rating links. The study reveals a lack of research in the subfield of transport electrification. The authors conclude that more research on sustainability criteria for fleet electrification is needed to support a smooth transition to EVs within this specific subfield of transport and to contribute to emission decrease in transport sector.

Keywords – Climate change; e-mobility; sustainability assessment criteria; systematic review; VOSviewer

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BIODIESEL WITH FUEL ADDITIVE: AN ANALYSIS OF ENGINE PERFORMANCE, COMBUSTION AND EMISSION CHARACTERISTICS

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Abstract – Threats to the environment from exhaust emissions and global warming continue to generate more calls by most governments to end the use of fossil fuels and switch to green fuels. This study aims to examine one of the green fuels that is seeing rapid expansion, namely the biofuel known as biodiesel. Biodiesel is non-toxic, biodegradable, made from renewable sources and can reduce diesel engine exhaust emissions. Even though one of the technical benefits of biodiesel is its ability to be oxygenated in diesel engines without much hardware modifications; however, it has been unable to reduce exhaust tail emissions from diesel engines on its own. In this research, the impact of biodiesel mixed with oxygenated additive, diethyl ether, when subjected to performance, combustion, and emission tests in unmodified diesel engine at different speeds has been studied. Waste cooking oil was transesterified using methanol as a reagent and NaOH as catalyst. The biodiesel was blended manually at room temperature with diesel fuel and diethyl ether in different proportions while keeping the volume of diethyl ether constant at 10 %. The fuel blends (B10D90, B20D80, B30D70, B10A10D80, B20A10D70, and B30A10D60) were subjected to performance, combustion, and emission tests in a single-cylinder, four-stroke diesel engine coupled to a water-cooled Eddy current dynamometer and results obtained compared with diesel fuel. The results showed that all performance characteristics (brake power (BP), brake torque (BT), brake thermal efficiency (BTE) and brake specific fuel consumption (BSFC)) improved with B10A10, which was found to closely resemble diesel. The peak cylinder pressures were higher for the blends, while the cylinder temperatures were comparable to those of diesel. The carbon monoxide (CO), carbon dioxide (CO_2), hydrocarbon (HC) and oxides of nitrogen (NO_x) emissions decreased more for all tested blends than for those of diesel at all engine speeds. Adding diethyl ether additives improved the physicochemical properties of biodiesel, making it a viable method for using biodiesel efficiently in diesel engines without modifying the engine. The study found that using green diesel fuel with a diethyl ether additive is a potential step toward improving air quality by lowering emissions from stationary, and transportation engines while maintaining optimal engine performance. As a result, using biodiesel-diesel fuels with the appropriate proportions of diethyl either additive has the potential to reduce greenhouse gas (GHG) emissions and ensure benign environment.

Keywords – Biodiesel; compression-ignition engine; diethyl ether additive; fossil fuels; green fuels

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BIOMETHANE PRODUCTION AND UTILIZATION PATHWAYS: AN MCDA-BASED IMPACT ASSESSMENT IN SARDINIA, ITALY

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Abstract – Biogas from the anaerobic digestion of organic substrates represents a renewable and sustainable fuel widely deployed in Sardinia, supported by the high share of rural areas and the generation of agro-industrial residues and by-products. On the wave of new economic incentives, interest is gradually shifting to biomethane. Nonetheless, the possible uses of biomethane are compelled by the local energy system, which defects in the implementation of the natural gas grid and gas fuelling stations. This is the reason why heat and power production may still be considered one of the most plausible biomethane utilization. Multiple options for upgrading biogas into biomethane exist. Chemical absorption represents an established and reliable upgrading solution. However, innovative alternatives such as biological methanation have emerged characterized by high sustainability and versatility. In the present paper, six scenarios for biomethane generation and utilization are presented and analysed to determine an integrated impact benchmark for each of them. The impact assessment is structured in criteria that depict the environmental, economic, technological and social dimensions. It is carried out using the Multi-criteria Decision Analysis. An in-depth literature review allowed to identify quantitative and qualitative indicators for each dimension according to a rationale described in the paper. The results describe the processes and technologies involved and determine the integrated impacts for the considered scenarios. The method adopted emphasizes the regional worth of the assessment process, and the critical importance of collecting technological data at the pilot or commercial scale, given the distinctiveness of the experiences developed at the laboratory-scale.

Keywords – Assessment; biomethane; impact; multi-criteria decision analysis

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BUSINESS AS USUAL FOR THE BIOMASS ENERGY SECTOR? STATE OF THE ART AND FUTURE AVENUES

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Abstract – Many companies are increasingly confronting the challenge of changing their business models as they face a future in which energy solutions are needed that are environmentally, socially, and economically sustainable. Too often, the development process is sequential and stepwise rather than parallel, especially as far as dealing with technological, sustainability, and economic issues. This paper identifies trends as well as challenges and complications in the use of biomass from a business model perspective and address future avenues. We conduct a systematic literature review to identify state of art in the field of business model development in the biomass energy sector. We use several databases to identify international, peer-reviewed research articles published between 2002 and 2022. Our review presents data from more than 200 articles including author affiliation by country, article publication date, article title, journal of publication, journal impact factor, country of empirical data, unit of analysis, research methodology, and research area addressed. The research areas identified include: (i) biomass as an energy source with multiple applications from small-scale household use to large-scale industry use, (ii) biomass as a renewable resource developed based on industrial and political initiatives, (iii) the feasibility of conventional bioenergy, (iv) the industrial ecosystem, stakeholders, and the business environment in the biomass industry, and (v) biomass as a potential energy source that can mitigate the harmful effects of climate change. Although much of this research on the use of biomass takes a technological, logistical, or incentives perspective, our literature review reveals that an increasing body of research takes a business model perspective. This is a promising development, since the future use and growth of biomass as a sustainable resource depends on the successful development of biomass business models that are sustainable in every aspect – social, environmental, and financial. Conclusions drawn from the literature review indicate that the business model researched has mainly focused on three of the building blocks: value proposition, value creation and delivery, and value capture. The building block, value intention, merits more extensive study. This is especially relevant when developing sustainable business models that can meet many of the societal/environmental challenges as defined by the United Nations in its Agenda for Sustainable Development.

Keywords – Biomass; business model; literature review; value building block

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COMPARATIVE ANALYSIS OF THE CO_2 EXTRACTION FROM BIOGAS ABSORPTION PROCESSES EFFECTIVENESS

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Abstract – Currently, the developed EU countries have implemented biomethane production projects from biogas, supply it to natural gas distribution grid with subsequent production of electricity or (and) heat, and use biomethane as motor fuel or supply to the gas network. It is also extremely relevant for Ukraine, supposing the problems with gas import due to Russian aggression and the presence of a large agricultural potential. The concern that arises is the rational choice of the technology for producing biomethane from biogas. The Gas Institute of the National Academy of Sciences of Ukraine has extensive experience in the development of technologies for the biogas collection, its direct usage, and CO_2 extraction by the amine absorption method. Some of the technologies have been implemented at landfills in Ukraine. Data on other methods of CO_2 extraction are widely available in world publications, so the authors compared the technologies from the point of view of their practical use possibility. Using computer modeling, the energy costs during the production of biomethane from biogas using the most advanced amine and water absorption processes for cleaning biogas from carbon dioxide were analysed. The combined water-amine absorption method of biogas purification from CO_2 was included in the comparative analysis in which carbon dioxide was previously removed by water absorption at a pressure up to 0.3 MPa and output finally purified by amine absorption. Calculations for amine technology are verified in a pilot study. For a range of the CO_2 concentration in biogas 32–42 % vol., the specific energy consumption when using water absorption, the extraction of carbon dioxide from biogas is on average two times less compared to amine absorption, but at the same time the loss of CH_4 due to its solubility during water absorption amounted to 7.1–7.6 %, with practically no losses of CH_4 in amine absorption, and minor losses (0.17–2.8 %) in combined water-amine technology. The energy consumption of combined water-amine absorption is comparable to that of water absorption due to: a) reduction of heat losses for regeneration process of saturated amine absorbent, as part of CO_2 has already been removed with water technology; b) using the CH_4 excess to compensate power consumption of the biogas compressor during the preliminary water absorption of CO_2 and/or to compensate heat costs of the saturated amine absorbent regeneration. The results of extracting carbon dioxide from biogas processes modeling can be used to optimize technological absorption schemes for the production of biomethane, an analogue of natural gas.

Keywords – Absorption; amines; biogas; biomethane; carbon dioxide; landfills

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PERSPECTIVES OF SMALL-SCALE HYDROPOWER ENGINEERING IN UKRAINE

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Abstract – Every country takes care of energy independence and security by using different energy sources and remarkably increasing electricity production by renewable energy sources. Ukraine is not an exception, especially when the energy infrastructure is significantly damaged during the war and there is a lack of capacities in the energy system. Because of this, the Government of Ukraine is planning a number of measures to launch systems of domestic mini-power plants. Ukraine has favourable conditions for developing the network of small-scale hydropower plants. While the hydropower potential of the largest Ukrainian rivers is used, the potential of small rivers is used only partially. The small-scale hydropower plants were built during the last century very actively. In 1912 the first small-scale hydropower plant was built. From 1923 to 1960, there were 956 hydropower plants with different capacities from a few kW to a few MW. However, at the end of the 1980s, the interest in small hydro decreased because of the construction of the large hydropower plants in the river Dniester and Dnipro, heat and nuclear power plants. Only 49 plants were in operation. Since 1995 the interest in small hydro has increased again. Nowadays, there are about 150 hydropower plants in operation. The paper examines the past and present state of small hydropower plants and perspectives on their development in the future, both by building new or reconstructing existing power plants. The list of hydropower plants with a short description of possible reconstruction is given. Moreover, the way of reducing the negative influence of hydropower plants on the environment is studied. Taking into account the energy issues in Ukraine, the possibilities of off-grid operation of hydropower plants are considered. The importance of energy security was evident from the issues that Ukraine is recently facing. Building new and reconstructing old small-scale hydropower plants will help to ensure the energy security of other types of electricity generation.

Keywords – Energy security; environmental impact; hydropower potential; renewable energy sources (RES); small hydropower plants (SHPPs)

Acknowledgement

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PRODUCTION OF BIODIESEL FROM WASTE VEGETABLE OIL (WVO) USING NANO CAO-NCC CATALYST: MODELLING AND OPTIMIZATION USING CENTRAL COMPOSITE DESIGN (CCD) IN RESPONSE SURFACE METHODOLOGY (RSM)

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Abstract – Biodiesel production as a fuel in diesel engines has expanded dramatically in recent years and is likely to increase more in the near future. Increasing biodiesel consumption requires optimized production techniques that allow for significant production capacities, simplified operations, high yields, and the usage of more cost-effective feedstocks such as waste oils and fats. In this study, biodiesel was produced from waste vegetable oil (WVO) and Methanol (CH_3OH) in the presence of a nanoCaONCC catalyst that was derived from industrial waste that mainly consists of Calcium Carbonate ($CaCO_3$). The produced nanoparticle catalyst was characterized by using FTIR, SEM, and XRD. Response surface methodology (RSM) was used to determine the optimum operating conditions for the highest biodiesel yield. After applying the RSM methods using the CCD experimental design, the optimum biodiesel production was found to be at a temperature of 55 °C, catalyst loading of 1.25 % w/v, Methanol to oil ratio of 1:5 w/w, and reaction time of 75 min with an average yield of 94.01 %. The FTIR showed the presence of the CaO and NCC functional groups. SEM image revealed that the produced catalyst is more porous, with a small particle size. The XRD pattern presented the presence of cellulose (NCC) and Calcium Oxide (CaO) nanoparticles in the synthesized catalyst. The R^2 of 0.963 was found to be for the mathematical models to predict biodiesel production

Keywords – Biodiesel; composites; nano-catalyst; nanocrystalline cellulose; nanoparticles

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CARBON NEUTRALITY IN MUNICIPALITIES: BALANCING LOCAL AND CENTRALIZED RENEWABLE ENERGY SOLUTIONS

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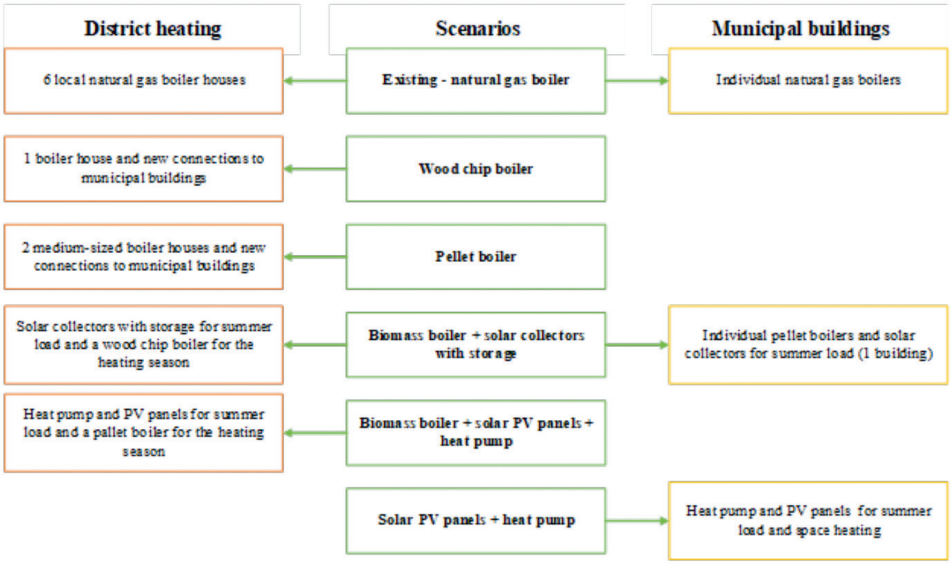
Abstract – Carbon-neutrality in municipalities can be achieved by combining individual heating (IH) and district heating (DH) solutions involving the use of renewable energy sources (RES). Each approach has advantages and disadvantages, but the best solution depends on the specific circumstances of each municipality. As an environmentally friendly and efficient energy use, a decentralised heat supply contributes to achieving energy conservation and emissions reduction goals. Decentralised energy use, such as solar collectors with an accumulation system or biomass as a resource, reduces dependence on centralised heat generation and transmission. Often, the appropriate infrastructure for connection to DH networks has not yet been built. On the other hand, it is easier to make investments to construct proper infrastructure in the case of large-scale centralised heat supply. Moreover, a centralised heat supply with RES can provide more inhabitants with RES heat energy. Within the framework of the study, the possibilities of using renewable energy sources in one of the municipalities of Latvia – the Carnikava parish of Ādaži Municipality – are analysed. The study examines two scenario complexes including IH solutions in buildings or DH solutions with a centralised approach. The study evaluates several alternatives to increase the share of RES (e.g., solar collectors, biomass, heat pumps, etc.) in the centralised heat supply. To evaluate RES individual solutions in various municipal buildings, the study evaluates alternatives with different technical solutions that increase the use of RES in heat supply.

Keywords – Carbon neutrality; district heating; individual heating; municipalities; renewable energy



Development of scenarios for district heating and municipal buildings.

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MODEL PREDICTIVE CONTROL OF GRID-CONNECTED BATTERY SYSTEMS TO AVOID PV-INDUCED OVERVOLTAGE

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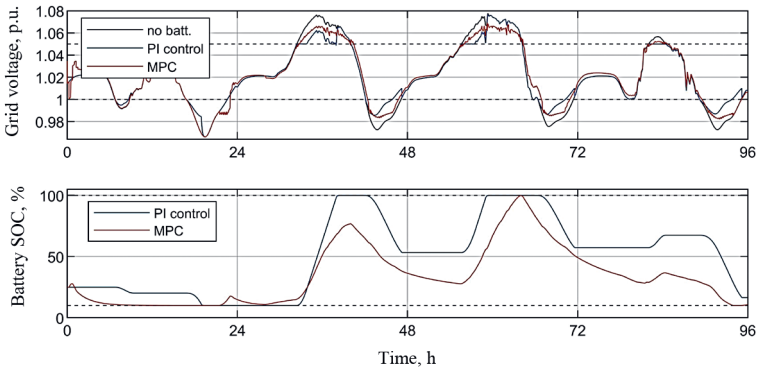
Abstract – Photovoltaic (PV) power plants are currently built at a high rate, both small ones for single family houses and large-scale plants with a power output in the MW range. This development accelerated even more since the beginning of the energy crisis in 2021. Due to intermittent energy production, large voltage swings may result in the electrical grid, which are challenging for grid and operators. We are considering the problem of overvoltage in times of excessive PV production, which is well documented in the literature. To avoid overvoltage, without PV-curtailment or grid expansion, grid-connected battery systems are proposed. The research focus is on advanced control strategies for such systems which charge and discharge at appropriate times to reduce the overvoltage in the grid while simultaneously minimizing the required battery capacity. The work presented extends a previous contribution of the authors. The analysis was done in a simulation environment (MATLAB/Simulink). The case-study shown considers a 5 MW PV plant connected to the 10 kV grid level, where load profiles of residential areas and commercial areas were analyzed. A mathematical model of the grid behaviour was estimated from regular grid operation data using system identification methods. The model predicts grid voltage from solar irradiation and grid load. A model predictive controller (MPC) was designed with the aim to keep the averaged grid voltage magnitude on all lines in-between upper V_{Grid}^{U} and lower V_{Grid}^{U} bounds. The MPC makes use of load and irradiation predictions, enabling a proactive charging and discharging of the battery to avoid large voltage peaks. A graphical result is shown below, where 4 days of simulation were compared with 3 different setups: 1) no battery in the system, 2) a battery controlled with a standard PID-type controller, and 3) the advanced MPC control. The 10kV (nominal) grid voltage is shown in the top panel, the state of charge of the 5 MWh battery in the lower panel. While the PID controller is able to reduce the voltage swings, the MPC can improve the performance further, since it has knowledge of future load and irradiation and can anticipate the overvoltage occurring, for example, between time 50–60 h and discharge the battery prior. Using the integrated squared deviation from V_{Grid}^{U} as performance criterion, we obtain 18.75 (no battery), 9.08 (PID control), and 7.07 (MPC).

Keywords – Power grid; photovoltaic; resilience



Acknowledgement

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PROFITABILITY ASSESSMENT OF WINDFARM OVERPLANTING IN SPAIN

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Abstract – The efforts made by European institutions to decarbonise the electricity system over the last decade have led Spain to become the fifth country in the world in terms of wind power plant capacity in 2021. This major achievement is still far from being able to contain and limit CO_2 emissions. By 2030, it is expected that, together with photovoltaic energy, Spain will reach 74 % of renewable generation in its electricity system. Wind technology is currently very mature in onshore wind farms and its relatively low cost makes this technology attractive to investors. However, the best wind sites were the first places to be occupied by the first turbine generations. On the other hand, newer wind farms occupy sites with less wind resource but have more efficient turbines. To improve the profitability of the wind farm and increase its production, the feasibility of other alternatives such as overplanting or storage is beginning to be investigated. Overplanting aims to optimise the use of the transmission system by increasing wind capacity above the transmission capacity limit. In this work, we measure the profitability of an overplanting strategy by quantifying the parameters that make profitable the investment. The developed model optimised the production of energy taking into account technical and financial parameters in order to cover a wide range of *situations*. We analysed the case of a specific site with 25 2 MW turbines with the Python tool PyWake. The results obtained show that for each new turbine the annual energy produced (AEP) grows by around 3.87 GWh per turbine added (a cut of 1.69 GWh due to congestion of the transmission system). The study shows improvements in profitability when the electricity price exceeds 70 €/MWh.

Keywords – Capacity optimization; overplanting; wind energy

Acknowledgement

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SYNTHESIS OF NANO-CALCIUM OXIDE FROM INDUSTRIAL BRINE SLUDGE WASTE WITH NANOCRYSTALLINE CELLULOSE (NCC) AS ADDICTIVE/COMPOSITES AND MODELLING USING ARTIFICIAL NEURAL NETWORK (ANN) FOR BIODIESEL PRODUCTION

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Abstract – Biodiesel production as a fuel in diesel engines has expanded dramatically in recent years and is likely to increase more in the near future. Increasing biodiesel consumption requires optimized production techniques that allow for large production capacities, simplified operations, high yields, and the usage of more cost-effective feedstocks such as waste oils and fats. In this study, biodiesel was produced from waste vegetable oil (WVO) and Methanol (CH_3OH) in the presence of a catalyst which was derived from industrial waste that mainly consists of Calcium Carbonate ($CaCO_3$). The produced nano-particle catalyst was characterized by using Fourier Transform infrared (FTIR), Scanning Electron Microscope (SEM) and X-ray diffraction (XRD). The optimum operating conditions for the highest biodiesel yield after applying the artificial neural network (ANN) approach was found to be 96.41 % yield at a temperature of 55 °C, catalyst loading of 1.25 % w/v, Methanol to oil ratio of 1:5 w/w and reaction time of 75 min. The FTIR showed the presents of CaO and NCC functional group. SEM image revealed that the produced catalyst is more porous, with small particle size, and XRD pattern presented the presence of cellulose (NCC) and Calcium Oxide (CaO) nano particles in the synthesized catalyst. The R^2 of 0.977 was found to be for the mathematical models to predict biodiesel production.

Keywords – Biodiesel; composites; nanocrystalline cellulose; nano-catalyst; nanoparticles

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THE COMPARISON OF RES SUSTAINABLE DEVELOPMENT IN THE MAIN SECTORS OF ECONOMY

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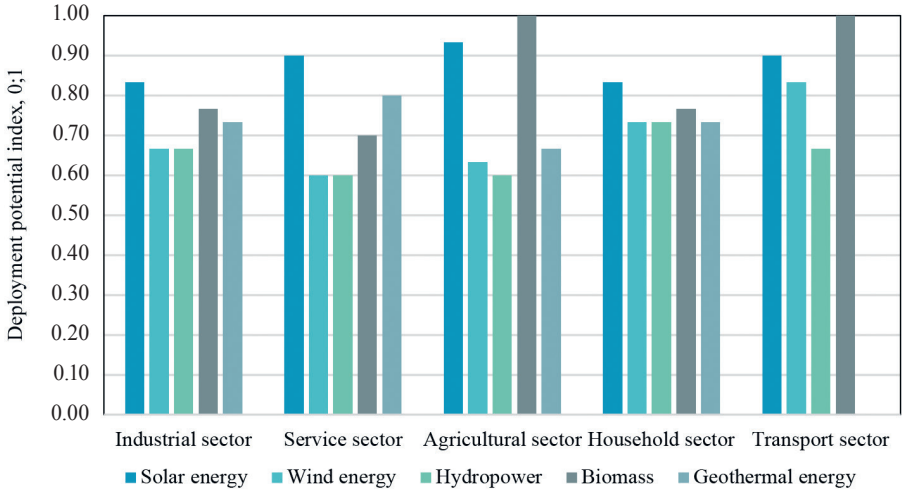
Abstract – Energy consumption in different sectors is responsible for more than 75 % of total EU greenhouse gas emissions. Energy is a priority when it comes to achieving climate goals and keeping greenhouse gas emissions low. The Green Deal is based on the need to use renewable energy sources in the energy sector while ensuring the replacement of fossil fuels and reducing energy dependence. The comparison of sustainable development trends in renewable energy sources (RES) is carried out for all sectors analysed in the study, such as industry, services, agriculture, transport and households. The aim of the study is to find out which of the types of RES is the most promising and sustainable in each sector and which factors influence this the most. The study develops a model that combines both qualitative and quantitative research methods to obtain the most objective and descriptive results possible on RES technologies in different sectors of the economy. In addition to a separate comparison of RES types by sector, a joint sectoral comparison was also made to evaluate the differences in development trends between the sectors considered. The highest rating level for sustainable development was achieved by the potential of biomass use in the agriculture and transport sectors. According to the obtained results, both solar energy and biomass have a high development potential in all analysed sectors, which is also reflected in the higher average values of the overall results.

Keywords – Comparison; development; renewable energy; sustainability; technologies



Comparison of the development trends of RES between the sectors.

https://doi.org/10.7250/CONECT.2023.086

THE RAW MATERIAL BASE OF BIO-WASTE FROM PROCESSING AS AN OPPORTUNITY FOR THE DEVELOPMENT OF THE BIOGAS SECTOR IN POLAND

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Abstract – Given the current geopolitical situation, as well as ongoing climate change, immediate action is imperative to develop sustainable energy production capacities and circular bioeconomy chains. The biogas sector, including 3rd generation biogas plants, can respond to intensive development pace ensuring sustainable energy production with lower carbon footprint. This is true for Poland, which has a highly developed agricultural and food production sector but a limited number of biogas plants and no biomethane production facilities. In this study the authors' objective is to support evidence-based policy advice by providing spatial analysis of bio-waste production potential in Poland. For this purpose, data was extracted from the so-called Waste Database (Polish: Baza Danych o Odpadach – BDO) and presented at district (powiat) level. Spatial and Geographical Information System (GIS) was applied to allocate waste resource potential for Poland related to national and regional development of biogas sector in the country. Thus the functioning of a system for the registration of waste data, including bio-waste from processing, is an outcome to demonstrate available resource availability per each manufacturing sector. Results indicate that Poland does have a quantitative and qualitative bio-waste potential for biogas production. Most of the bio-waste is not treated in the districts where it is generated. Having knowledge of the geographical distribution of the feedstock supply and demand, together with the use of other substrates, the authors can provide valuable information for the development of the biogas sector at regional and national level.

Keywords – Bioeconomy; biogas; bio-waste; GIS; Poland

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THE ROLE OF HYDROGEN IN FUTURE CLIMATE-NEUTRAL ECONOMY

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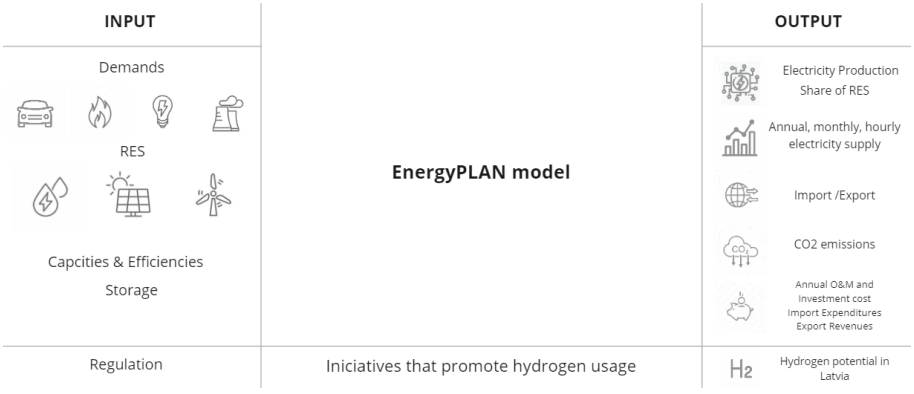
Abstract – Global annual CO_2 emissions have increased more than 16 times in 2021 compared to 1990 and are expected to keep growing. Renewable energy is a critical way to reduce the impact on the climate. However, renewable energy production's power output does not necessarily match the demand. The intermittent character of renewable electricity generation requires the storage of produced energy. Green hydrogen production via electrolysis is an opportunity to increase the integration of renewable energy sources and move hard-to-decarbonize sectors to climate neutrality. This research aims to assess the potential role of hydrogen in decarbonizing the energy sector in Latvia in the long term. Latvia's energy system is modeled using the input/output deterministic energy system analysis model EnergyPlan. The model includes all the primary energy demand sectors, energy production, and storage, and allows the analysis of the impact of different strategies on the total costs and emissions of the system by 2050. The results show that the production potential of green hydrogen will increase significantly by 2030, taking into account the existing plans for the installation of 800 MW of wind and solar generating capacity on a national scale. The most significant potential is associated with using hydrogen in the transport sector in vehicles and in producing alternative fuels. Other uses include the decarbonization of the natural gas sector. In these scenarios, it is possible to reduce CO_2 emissions while annual system costs increase.

Keywords – CO_2 emissions; EnergyPLAN; hydrogen; renewable energy sources; RES



An overview of EnergyPLAN and how it was used in this study.

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UNLOCKING THE IMPACT OF CLIMATE CHANGE MITIGATION POLICIES: A COMPREHENSIVE STUDY OF CLEAN AND DIRTY INNOVATION DYNAMICS

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Abstract – Achieving the Paris Climate Agreement's goal of limiting global warming to 1.5 °C to 2 °C by the end of the century will require massive investments in environmental technologies and a drastic shift away from high-carbon technologies. This paper investigates the impact of climate change mitigation policies on clean energy innovation. A statistical evaluation of the impact of public policies on the rate and direction of innovation for a lowcarbon future is complicated by the nature of the data and the absence of benchmarks. In addition, the statistical analysis is further complicated by the spillover effects between clean and dirty innovation and by the lag effects. In this paper, the authors assess the effects of both public policies, such as carbon taxes and green subsidies, and economic and environmental conditions, such as oil prices, large recessions, climate-related disasters, etc., on clean innovation using a nonparametric method based on the copula distribution of clean innovation. The authors collect data from the European Patent Office (EPO) Worldwide Patent Statistical (PATSTAT) Database, both on clean and dirty patents. This database is managed by the EPO and compiles data from patent offices around the world. The emphasis is put on inventions for which a patent application has been submitted to the United States Patent and Trademark Office (USPTO). The inventions are dated based on the date of their first patent application. Clean innovation refers to patents in areas such as renewable energy generation and electric vehicles, while dirty innovation refers to fossil-based energy generation and internal combustion engines. The authors employ a novel nonparametric test against pairwise differences, especially in tail dependence structures, which we measure with tail copulas, thereby avoiding the possibility of parametric misspecification. This method also permits to examine the effects of various interventions and economic conditions on different portions of the distribution, with a particular emphasis on tail dependence. The authors identify nonlinear dependence structures between clean innovation, public policies, and economic determinants like the oil price and recession. By comparing the effects of clean and dirty innovation, we can determine whether the effect on clean innovation is distinct. The findings indicate that the tightening of environmental policies since the early 1990s has statistically and economically contributed to the increase in clean innovation. The findings can bolster public support for green R&D. In addition, they suggest that green policies may be able to increase the knowledge diffusion of clean innovation.

Keywords – Climate change; clean and dirty innovation; climate change mitigation policies; nonparametric test

05

LOW CARBON DEVELOPMENT AND BIOECONOMY

https://doi.org/10.7250/CONECT.2023.089

DO NON-FORMAL AND INFORMAL EDUCATION IMPACT REACHING THE BIOECONOMY AND GREEN DEAL GOALS?

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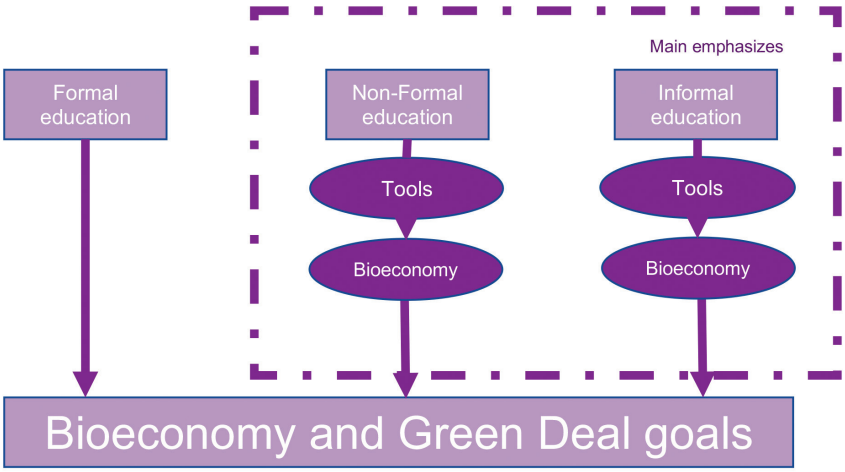
Abstract – To achieve the goals of the bioeconomy, formal education is a cornerstone, as well as non-formal or lifelong learning and informal education. Professionals in their specific profession can expand their knowledge in the context of bioeconomy in non-formal education by attending various seminars and courses, acquiring knowledge in informal or self-education, and reading books, internet sources and other resources. Competencies in the bioeconomy are a cross-cutting element for a professional working in any field. RTU IESE is a leading institution providing non-formal and informal education in bioeconomy and Green Deal topics. This study aims to identify the potential of non-formal and informal education in achieving the goal of bioeconomy and the Green Deal. Non-formal and informal education is an essential type of education that can increase bioeconomy competencies for professionals. Seminars, conferences, courses, lectures, and workshops are non-formal education tools, but with informal – everyday learning (books, scientific papers, conversations, internet resources, TV, audio materials) it can be accelerated to reach bioeconomy and Green Deal goals faster.

Keywords – Climate neutrality; non-formal education; sustainable education



Acknowledgement

This work has been 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" of the Specific Objective 8.2.2 "To Strengthen Academic Staff of Higher Education Institutions in Strategic Specialization Areas" of the Operational Programme "Growth and Employment".

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GHG SAVINGS CALCULATION: SWITCH FROM ELECTRICITY PRODUCTION TO BIOMETHANE. CASE STUDY

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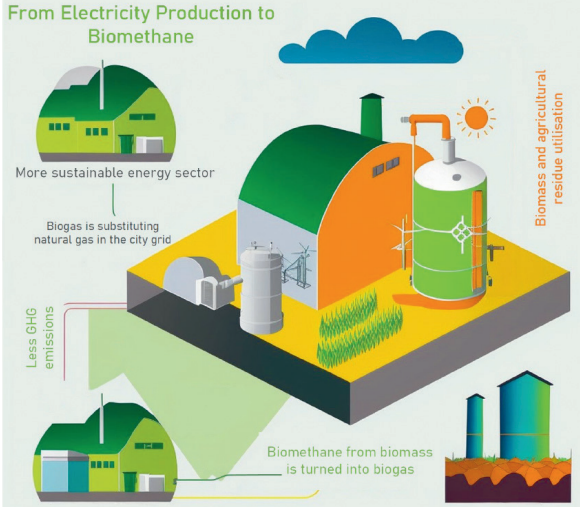
Abstract – Carbon dioxide is one of the main components of greenhouse gases. The amount of anthropogenic CO_2 emissions in the atmosphere reached 37.9 Gt, which is 60 % more than in 1990. The use of CO_2 in the production of valuable products can help to reduce the amount of CO_2 in the atmosphere. Biomethane fuel production could be a successful solution in Latvia as well. The work includes a case study of a Latvian biogas production facility Agro Iecava with a switch from biogas to biomethane production. All calculations are made according to REDcert rules. For biofuel production the Plant uses 13 types of substrates, which is also reflected in the calculation. The work shows a step-by-step algorithm for research and analysis. The experience can be used at other biogas production stations, regardless of its location. The analysis of the Plant shows that switching to biomethane production saves up to 80.34 % of GHG emissions (with an estimated loss during transportation in the network of 1 %). In the worst-case scenario, this amount is 76.34 % (loss from transportation is 5 %), which is also above the minimum indicated in the Renewable Energy Directive.

Keywords – Biogas; biomethane; fuel; GHG; GHG calculation; Latvia



Acknowledgement

This work has been 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" of the Specific Objective 8.2.2 "To Strengthen Academic Staff of Higher Education Institutions in Strategic Specialization Areas" of the Operational Programme "Growth and Employment".

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INSIGHTS OF BIOECONOMY: BIOPOLYMER EVALUATION BASED ON SUSTAINABILITY CRITERIA

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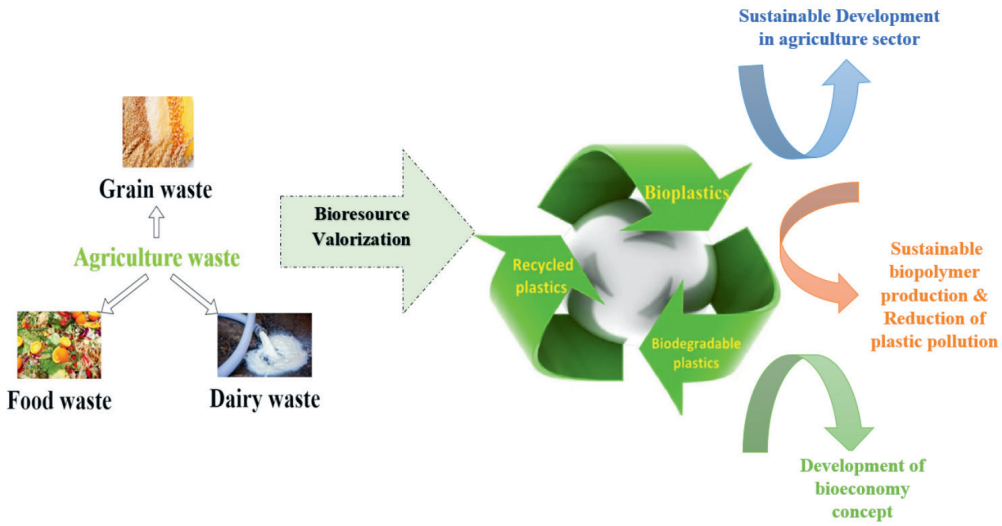
Abstract – Sustainable development in the agriculture sector can be boosted by integrating a sustainable bioeconomy and transforming renewable resources into added-value products. There are various methods to determine, measure, and compare the extent of sustainability. We promote the bioeconomy concept by utilizing agricultural waste in biopolymers considering the sustainable development in the agriculture sector. This research aims to evaluate biopolymer alternatives based on sustainability criteria and indicators using the integrated multi-criteria decision analysis approach under the sustainability umbrella. The authors evaluated the PLA, PHA/PHB, starch, protein, and cellulose-based biopolymers. As a result, the cellulose-based biopolymer shows the best performance. The research findings provide valuable information to establish a sustainable pathway for biopolymer production for industries.

Keywords – Agriculture; AHP; biopolymer; MCDA; sustainable development



Sustainable biopolymer production.

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BIBLIOMETRIC ANALYSIS ON SUSTAINABILITY ASSESSMENT METHODS IN THE BIOECONOMY

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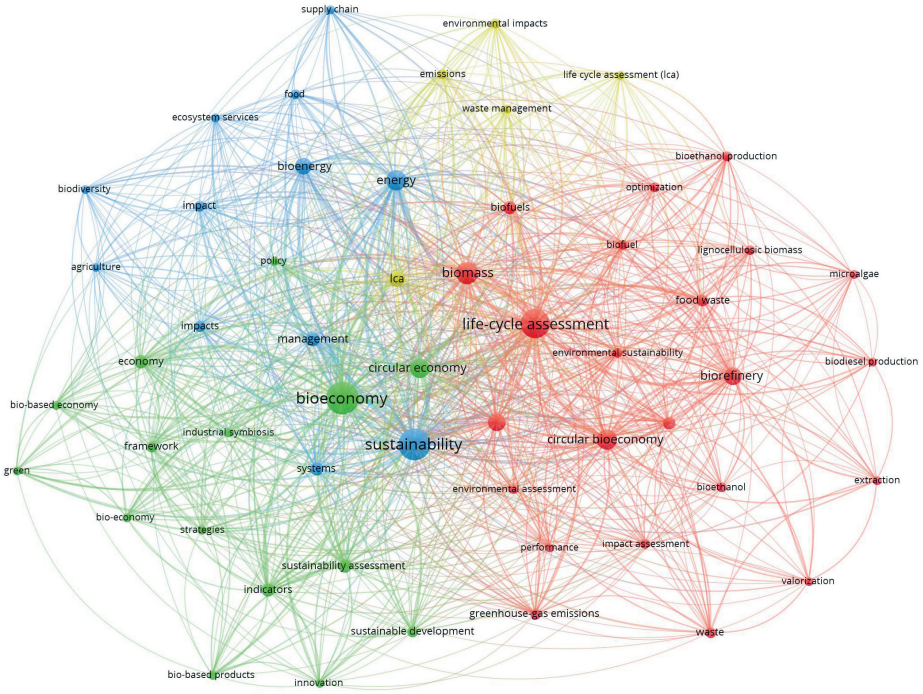
Abstract – Sustainability is meeting the needs of today without compromising the ability of future generations to meet their own needs. Sustainability assessment is a complex process because it needs to cover multidisciplinary aspects – environmental, economic, and social. The sustainability assessment is created by combining different indicators, and the resulting single holistic value can be used as an indicator for comparison. A successful economic transition towards a bioeconomy can contribute to the achievement of many sustainability goals. In this paper, a bibliometric analysis method is used to analyse Open Access articles from the Web of Science database using bibliometric *VOSviewer* software. The relationship between sustainability assessment methods and associated keywords is explored through a biometric analysis. A literature review is conducted on the methods and tools of assessing the sustainability of bioresources. The authors have summarised the use of sustainability assessment methods and tools, and their characteristics. The obtained results show that keywords' sustainability assessment methods, in publication have become particularly popular since 2015, as the number of publications increases by more than 100 publications every year. The biggest connection with keywords are keywords 'life-cycle assessment', 'performance', 'management', 'framework', 'model', and 'impact'. Life-cycle assessment, material flows analysis, multi-criteria decision analysis, system dynamics and modelling are popular for assessing sustainability. Each method has advantages and disadvantages; however, it is possible to combine several tools to improve the assessment.

Keywords – Bibliometric analysis; bioeconomy; evaluation methods; sustainability assessment



Keyword co-occurrence network for keywords 'bioeconomy sustainability assessment' or 'bioeconomy sustainability evaluation'.

Acknowledgement

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CHALLENGES AND BARRIERS FOR AQUACULTURE SECTOR: REVIEW ARTICLE ON FRESHWATER AQUACULTURE

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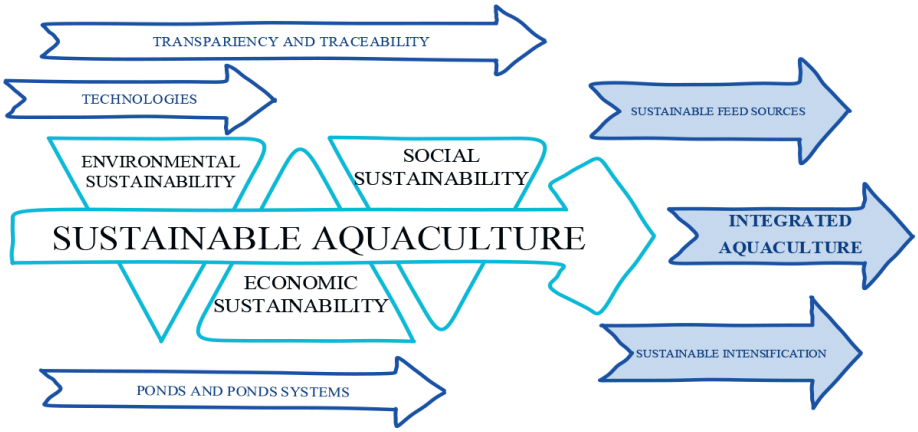
Abstract – The EU aquaculture sector, like other sectors of the EU economy, must participate in the 'green transition' set out in the European Green Deal. The sector has a particular role to play in contributing to the transition towards sustainable food systems and the development of the bioeconomy and circular economy. Aquatic organisms and fish cultivated in aquacultures are important sources of food and feed, the importance of developing which has been highlighted in several EU policy planning documents. Due to high nutritive value, fish and aquatic organisms are a valuable food source. Despite the rapid growth of aquaculture in Europe and other parts of the world, the promotion of sustainable or organic aquaculture is crucial for the provision of high-quality, locally accessible food. Aquacultures produce relatively low greenhouse gas emissions compared to sources of protein grown on land. However, there is still room for growth, therefore, to further reduce greenhouse gas emissions from aquacultures and foster more sustainable practices and greater resource and energy efficiency are required. This review article includes an analysis of policy planning documents adopted in Latvia and the EU, outlining opportunities and risks for creating a sustainable aquaculture industry. The purpose of this review article is to identify the most significant problems and obstacles to achieving a sustainable aquaculture system at both the local and European levels. In addition, the review investigates and contrasts recent advancements in aquaculture technological processes and socioeconomic impact factors. Whether aquaculture's path to sustainability is jeopardized by inefficient consumption of resources and wastes (feed, energy, emissions) at the beginning or end of the organisms' life cycle.

Keywords – Bioeconomy; circular economy; pillars; sustainable aquaculture



Towards sustainable aquaculture.

Acknowledgement

This work has been 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" of the Specific Objective 8.2.2 "To Strengthen Academic Staff of Higher Education Institutions in Strategic Specialization Areas" of the Operational Programme "Growth and Employment"

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INVASIVE PLANT BIOMASS AS SOURCE OF POLYPHENOLS

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Abstract – Invasive plant species contribute to problems related to the functioning of ecosystems, causing economic damage, damage to human health and reducing quality of recreational resources. They are characterized by rapid and aggressive spread, suppressing endemic species. For the full use of invasive plant biomass, it is necessary to find sustainable, bio-based control solutions, based on the knowledge of their composition. To increase awareness of possible usage of invasive plant biomass, the authors have chosen such plants as *Lupinus polyphyllus*, *Impatiens glandulifera*, *Heracleum sosnowskyi* and *Echinocystis lobata*, which make stands, and therefore mechanical harvesting can be used to collect plant biomass. In various parts of these plants, total polyphenols using the Folin-Ciocalteu method and antiradical activity using DPPH method are studied. The obtained amount of polyphenols in the analysed samples of plants and their parts are different with highest concentration in *Impatiens glandulifera* leafs reaching concentration 9.78–16.75 g GAE / 100g DW. Although in the case of *Lupinus polyphyllus*, the highest concentrations of polyphenols are identified in the methanol extracts of roots (24.85 g GAE / 100 g DW) and flowers (17.77 g GAE / 100g DW) of the plant as richest parts of polyphenols in the studied plants are leaves and flowers. The obtained results confirm the potential use of invasive plants biomass as a source of biologically active substances – polyphenols, after plants eradication.

Keywords – Biomass; invasive plants; polyphenols

Acknowledgement

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MAPPING OF THE BIOECONOMY ECOSYSTEM IN LATVIA

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Abstract – Bioeconomy is no longer limited to being a concept in research papers and policy strategies; it presents real opportunities for regional development, i.e., by improving local employment, socio-economic development, economy and sustainable local bioresource use. But the obtaining of these opportunities is challenged by various barriers. It is proposed that analogously with other widely research fields (energy efficiency, industrial sustainability), the implementation of novel bioeconomy ideas, even when they are scientifically based, encounters the so-called 'implementation gap' (similarly to, e.g., the 'energy efficiency gap'). This implementation gap is related to national, but also regional challenges, i.e., technical, economic, organizational, behavior and other barriers that hinder the most successful bioeconomy deployment. The technical obstacles can be, e.g., lack of processing or production technologies, capacity problems, while organizational barriers can manifest as logistics chain problems due to the availability of bioresources or internal organization problems of the company, lack of time, reluctance to take on new responsibilities or lack of awareness of opportunities provided by the bioeconomy. This significance of the regional analysis level for barrier assessment calls for more precise information. The first step for in-depth investigation of the bioeconomy implementation gap in Latvian context is the research of the bioeconomy ecosystem. In fact, as required by the National industrial policy guidelines, the Strategy for knowledge based bioeconomy development for Latvia was developed in 2022 by the Latvian bioeconomy ecosystem stakeholders. The current research focuses on the identification and more detailed characterization of the stakeholders of Latvian bioeconomy ecosystem, their interactions, as well as the identification of current challenges and barriers for knowledge-based bioeconomy and innovations development. In order to further elaborate the structure of the bioeconomy ecosystem, the mapping of ecosystem stakeholders was implemented.

Keywords – Barriers; bioeconomy ecosystem; knowledge-based bioeconomy; mapping; stakeholders

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MOBILITY AS SERVICE: HOW CHANGING TRAVEL USE HABITS WILL AFFECT THE TRANSITION OF CITIES TO CLIMATE NEUTRALITY

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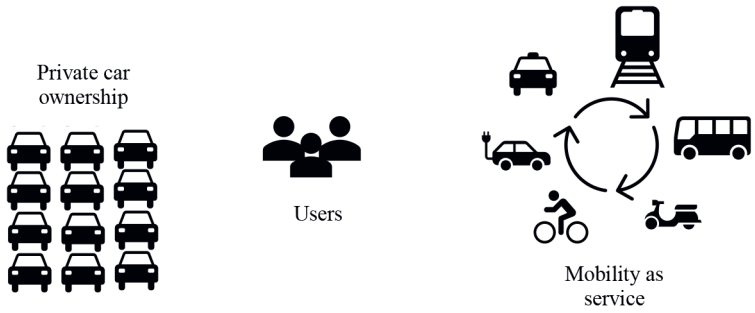
Abstract – Transportation contributes significantly to air pollution and carbon emissions in cities, negatively impacting human health and the environment. Mobility as a Service (MaaS) is considered one of the promising solutions to this problem, as it reduces the number of trips by private vehicles. MaaS integrates different modes of transportation such as buses, trains, bicycles, and cars into a single platform, which increases the attractiveness of shared transportation and micromobility tools for users and facilitates the shift from private cars to more environmentally friendly modes of transportation. MaaS brings tangible changes in transportation use behavior. Research on behavioral factors influencing MaaS use and their relationship to transportation habits is underdeveloped, especially in regions with high levels of private car use and low environmental awareness. This article presents the results of a survey aimed at identifying the factors that influence transportation user behavior and the policies needed to promote MaaS adoption. These data are then used to assess the impact of MaaS on cities' efforts to achieve carbon neutrality. The survey was conducted in the city of Riga, the capital of Latvia, and analyzes factors such as necessary changes in infrastructure, service design, pricing, public awareness, and information efforts to reduce carbon emissions.

Keywords – Behavior; city; MaaS; mobility as service; transport



Mobility as a service vs. private car ownership – paradigms of transport use.

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ON CARBON STORAGE AND SUBSTITUTION FACTORS OF HARVESTED WOOD PRODUCTS IN THE CONTEXT OF CLIMATE CHANGE IMPACTS OF THE NORWEGIAN FOREST SECTOR

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Abstract – Harvested wood products (HWP) contribute to climate change mitigation via two main mechanisms: carbon storage and substitution. The authors examined the data on carbon storage and substitution factors of HWPs that are relevant in evaluating the climate change mitigation potential in the context of the Norwegian forest sector. While there seem to be many uncertainties in these parameters, the data suggest that several uses of wood for industrial products come with clear carbon substitution benefits and, in some cases, provide long-term carbon storage. Such wood products could play an important role in climate-friendly bioeconomic transformation. In particular, the authors considered wood-based construction materials, textile fibres, and insulation materials as examples of such products with potential in future bioeconomy. The decay of the carbon stored in HWP pools over time is often modelled using the product half-lives that correspond to the number of years it takes for the carbon in a pool to be reduced to half of its initial value. Using the default half-life values of greenhouse gases reported to the United Nations Framework Convention on Climate Change, the average half-life of carbon in HWPs produced by the forest industry in Norway of today is approximately 21 years. Shifting some of the use of pulpwood and sawn wood chips from producing paper and pellets to produce insulation materials or panels for construction would increase the time carbon is stored in the HWP pool. Accounting for the large uncertainty in the carbon substitution parameters of HWPs found in this study, a cautious estimate of the substitution benefits of HWPs produced in Norway can be considered to amount to at least 5 Mt CO_2. Redirecting some pulpwood use from paper production to the production of textile fibres and the above-mentioned construction materials would increase the substitution benefits.

Keywords – Carbon displacement factor; forest industry; forest products; mean lifetime; wood-based insulation materials; wood-based textiles

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OPPORTUNITIES FOR BIOECONOMY DEVELOPMENT: A STUDY OF THE LATVIAN FOREST SECTOR AND IDENTIFICATION OF HIGH-VALUE NICHE PRODUCTS

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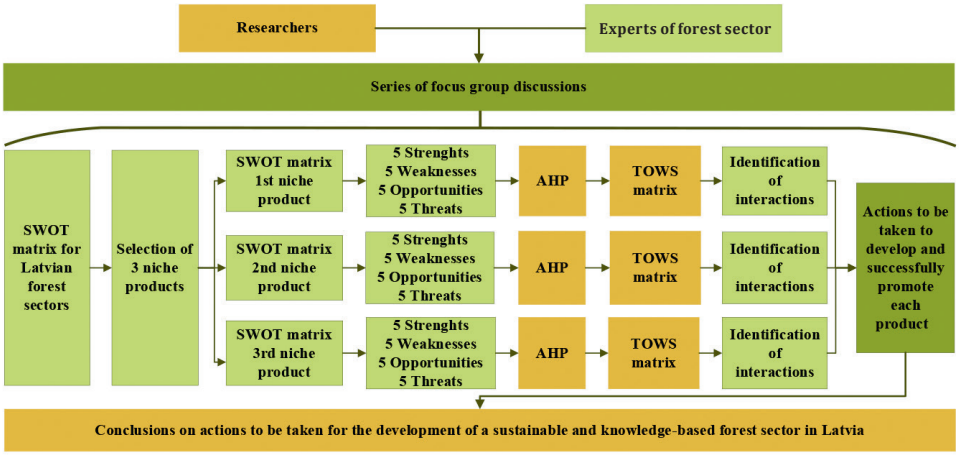
Abstract – Climate change, rising food and feed demand, and biodiversity loss necessitate a more sustainable, innovative, and knowledge-based bioeconomy. This research analysed and compiled statistical data, reports, and other official information from Latvian forest sector stakeholders to understand its system components. After identifying main enablers and constraints, a methodology was established to find niche products with high added value through which the potential of the forest sector could be built. The system components of the Latvian forest sector and future growth scenarios for wood-based niche products showed similar outcomes for current constraints and drivers for the bioeconomy and forest sector. As a result, a number of action measures were proposed at government and policy planning level; measures to strengthen research and development, and activities to promote the production of higher value-added products and the development of a sustainable bioeconomy.

Keywords – Bioeconomy; forest sector; niche products; value-added



Methodology for selection and analysis of niche products.

Acknowledgement

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PREDICTION OF CO_2 EMISSIONS USING MACHINE LEARNING

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Abstract – Carbon dioxide (CO_2) is one of the important issues concerning human evolution that drives global climate change. It is emitted from the combustion of fuels causing global warming. The global community has gradually turned to pay more attention to environmental issues. This paper implements four prediction models using Multiple Linear Regression (MLR), Support Vector Machine (SVM), Random Forest (RF) and Convolutional Neural Network (CNN, or ConvNet) to predict CO_2 trapping efficiency among CO_2 emissions, energy use, and GDP. The Machine Learning (ML) approaches used in this study have shown good performance with SVM and CNN models with MAPE. The result can be a significant model for the decision support system to improve a suitable policy for global CO_2 emission reduction.

Keywords – Carbon dioxide (CO_2); Convolutional Neural Network; Forecast; Multiple Linear Regression; Random Forest; Support Vector Machine

Acknowledgement

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SOCIAL LIFE CYCLE ASSESSMENT OF CO_2 VALORISATION SCENARIOS: CASE STUDY OF LATVIA

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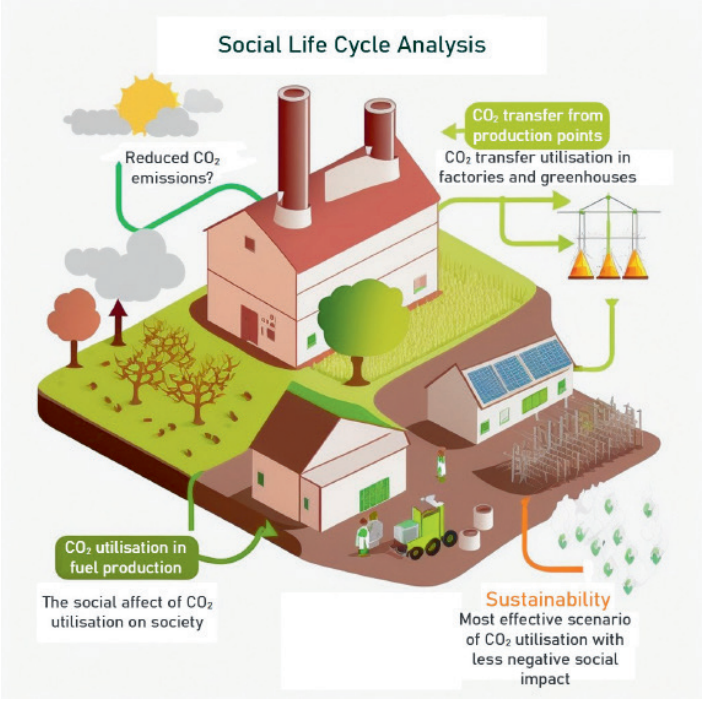
Abstract – As technologies develop, the question of their influence and effect on the environment and society becomes even more relevant. This is especially true for relatively young technologies that utilise or capture carbon dioxide. The Social Life Cycle Analysis is an indispensable tool to understand the impact of number of factors on the society and sociological factors due to various CO_2 valorisation scenarios in the mid-term to long term. The impact of scenarios on the public are identified based on a multi-regional input/output method of qualitative and quantitative generic data. This work takes into account aspects of health and safety, cultural heritage, the impact of various state structures on the interests of social groups – workers, local communities, society and consumers. The paper considers the factors of CO_2 valorization technologies that affect society both positively and negatively.

Keywords – Social LCA; CO_2; CCS; CCU; Latvia



Acknowledgement

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TOOL DEVELOPMENT FOR CARBON FOOTPRINT EVALUATION OF PACKAGING ALTERNATIVES

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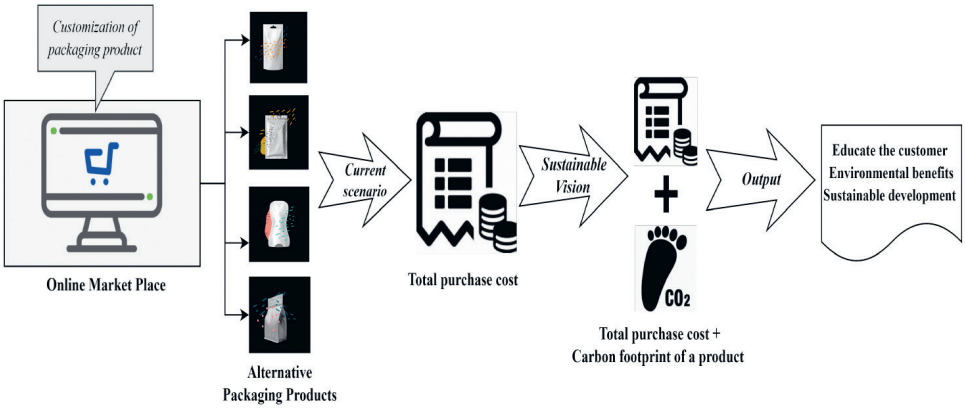
Abstract – With the increasing concern of pollution, any business willing to reduce its carbon footprint embraces sustainability and positively impacts the progress towards achieving climate neutrality. Well-prepared and presented information to the business customer before purchasing can be a strong driver for better decision-making towards less impactful product alternatives. This study presents the development of a tool that informs customers of an online marketplace for packaging products about the carbon footprint of customer-preferred packaging concerning possible alternatives and, in this way, promotes the reduction of packaging carbon footprint. For tool development, the LCA-based approach includes the raw material extraction stage, packaging production, and transportation to the customer. The impact assessment in the tool is performed according to Intergovernmental Panel on Climate Change (IPCC) 2021 methodology for assessing greenhouse gas emissions based on information obtained from the database *Ecoinvent 3.8*. The final output of carbon footprint calculation is provided with a colour indicator marking the carbon footprint performance of customer-defined alternatives clearly and simply to educate the customer, foster informed purchasing decisions, and improve environmental outcomes.

Keywords – Climate neutrality, GHG, life cycle analysis, online tool, packaging material



Carbon footprint tool for online marketplace.

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TRANSPORT EXTERNAL COSTS EVALUATION CASE STUDY

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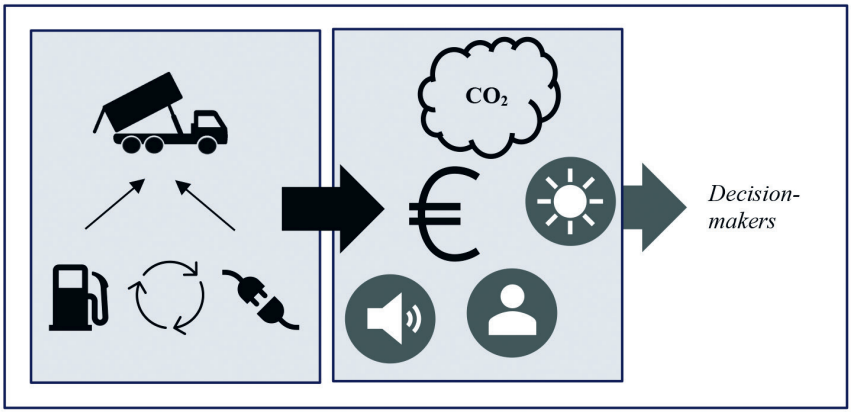
Abstract – With the European Union's goal of becoming a carbon-neutral region by 2050, its member states must follow suit. Businesses are among the actors that have a role to play in implementing this policy. Many companies have set such targets and often commit to becoming carbon neutral even earlier. However, businesses need an economic justification. Financial calculations are usually limited to analysing direct costs, equipment purchases, and maintenance costs, without considering other aspects. This case study examines the external costs of the transportation sector in a waste management company. Transport is the second largest source of greenhouse gas emissions in the EU after the energy sector and is characterized by increasing CO_2 emissions. Based on the company's case study, the external costs of the vehicles are calculated, which depend on the type of engine and energy used in the vehicles, as well as the travel patterns. In the scenario modelling, these external costs are compared with scenarios with a 100 % battery electric fleet. The results show that the total external costs decrease as the BEV share in the vehicle fleet increases. When analysing transport externalities of the substation project, air pollution, climate change, and noise costs decrease, while WTT emission costs increase.

Keywords – BEV; costs; CO_2; externalities; transport; waste



Stimulating businesses by including external costs in the assessment of the economic feasibility of fleet conversion projects.

06

CIRCULAR ECONOMY SYSTEM. SUSTAINABILITY

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A DECISION TOOL FOR WOOD WASTE VALORIZATION

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Abstract – Wood is an increasingly demanded biomaterial used in many fields: construction, materials, furniture, packaging, and energy. New consumption tendency indicates a major production of wood waste that is a starter for many processes. In Europe, about 54 % of wood waste is incinerated, while 46 % is recycled. In Italy, almost 95 % of wood waste is used to produce chipboard and particleboard. There are many other processes available to improve wood recycling; however, it is important to identify the best treatment way depending on the source matrix. Wood waste is a heterogeneous material that contains contaminating materials, pollutants, and additives. Hence, wood waste management depends on material composition analysis. In fact, it gives significant suggestions regarding how to manage the waste. From this point of view, a decision tool (DT) regarding wood waste destiny hinging on chemical composition is proposed. In particular, the DT gives rapid recommendation based on the chemical results. The most relevant elements considered are cellulose, lignin and hemicellulose content. In addition, pollutants, additives, and other contaminants are crucial to find the best pathway. Some available technologies make it possible to use wood waste for energy and heat generation, pulping, mulching, animal bedding, and other. Utilizing such waste could create job opportunities and generate income for the local companies. The utilization of wood waste in recycling can minimize the gap from supply and demand of lignocellulosic matter. Moreover, it prevents deforestation and contributes to the CO_2 offset process. Furthermore, it is possible to obtain add-value materials utilizing the right process for each determined substrate.

Keywords – Cellulose; hemicellulose; impurities; lignin; wood lower heating value; pulping; recycling; waste-to-energy; wood contamination

Acknowledgement

The authors would like to acknowledge Fondazione Perugia for funding 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).

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ANALYSIS OF TEXTILE CIRCULARITY POTENTIAL

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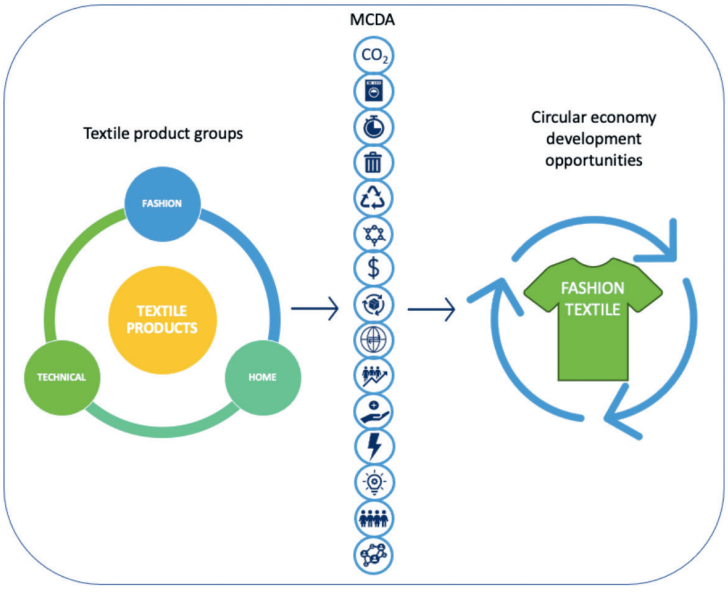
Abstract – Global annual textile consumption has doubled in the last two decades and is expected to keep increasing. Since the textile system operates primarily in a linear way, it is highly polluting and creates a lot of waste. Nevertheless, it has a high potential for circularity, since most textile products can be recycled or reused. Today most of the waste ends up in landfills, and less than 1 % is recycled back into textiles. This study aims to gather information and evaluate which textile product group has the highest potential for circular economy growth. It covers three main textile product streams: fashion, home, and technical textiles. The groups were compared using fifteen criteria: environmental impact, washes, landfilled waste, recycled waste, synthetic materials, projected lifetime, market demand, production, international trade, labour productivity, value added, technology energy efficiency, innovation capacity, employment, and enterprises. Indicative values have been found for each sustainability indicator by using and mathematically transforming data from the scientific literature. The evaluation method used in this study was multi-criteria decision analysis. The results indicated that the fashion textile group has the most significant potential for circular economy development.

Keywords – Apparel; circular economy; home textiles; multi-criteria decision analysis (MCDA); technical textiles; TOPSIS



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HOW ARTISANS APPLY CLEAN PRODUCTION: THE CIRCULAR ECONOMY OF HANDICRAFTS IN INDUSTRIAL CENTERS

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Abstract – Clean production in the production of handicrafts is one of the key elements of success for artisans in creating environmentally friendly products. The industrial waste generated by society has polluted the environment. Micro, small, and medium enterprises have a significant contribution to the Gross Domestic Product of a country. The presence of industrial centers that produce various types of handicrafts using clean production is expected to increase the income of artisans. The purpose of this research is to investigate the circular economy of handicraft artisans in producing products through clean production. The research used a descriptive qualitative approach, with artisans in Indonesian handicraft industrial centers as the subjects. Data collection was conducted through interviews and direct observations involving artisans in the industrial centers, as well as online data collection with relevant agencies. The research findings indicate that clean production in handicraft industrial centers is carried out using simple technology. This is influenced by the number of orders received by the artisans and based on sales turnover. The circular economy in the micro, small, and medium enterprises of handicraft industrial centers at the level of raw material usage, production processes, and marketing has already implemented environmentally friendly principles. However, the concepts of better service and remanufacturing are not present in the circular economy model applied in the industrial centers. This is due to the artisans' limited understanding and knowledge, as well as the function of the product itself.

Keywords – Circular economic; cleaner production; Small and Medium Enterprise

Acknowledgment

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FROM INCINERATION TO STERILISATION OF SOLID HOSPITAL WASTE IN LOW-INCOME CONTEXTS: A GRADUAL SUSTAINABLE TRANSITION

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Abstract – Open burning and incineration are the two most common treatments for hospital solid waste in low-income countries. Due to the absence of limits on emissions and the lack of technical capacity or funding, obsolete incinerators do not guarantee neither a low environmental and economic impact nor people health. The SIRSU Project, co-financed by the Italian Agency for Sustainable Development and Newster Group, aims to substitute the incinerator in Beira Central Hospital (Mozambique) with an electric sterilizer, an environmentally friendly machine that is also safe for workers. However, it is not sufficient to import this new technology and train the staff. First, an assessment of the quantities and types of biomedical waste produced in the different hospitals is necessary, as well as a careful analysis of the waste management system of all hospitals in the city. If the technology is suitable for the context, then, after the training of technicians for maintenance and operation, a period of accompaniment and monitoring is necessary to optimise performances. The transition cannot be immediate, and a period of coexistence of the two plants (steriliser and incinerator) is necessary. To facilitate the gradual transition, the SIRSU project foresees the foundation of a local start-up to manage the steriliser and offer a waste full transport service for smaller hospitals to the Central Hospital where the machine is installed. This experience could be an opportunity to set guidelines comprehensive of the concepts of safety and security during all the steps of the transition. This aspect can be an important element for defining 1) the most appropriate technical solutions, evaluating the implementations on the control and regulation systems in order to minimize the risks associated with the process, 2) management and above all operational methods in order to guarantee not only compliance with the most precautionary technical legislations, but also modern and advanced operating standards.

Keywords – Development cooperation; hospital waste; incineration; sustainability; technology development; sterilization; waste management; waste treatment

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GREEN TRANSFORMATION OF SCRAP METAL. MCDA AND SWOT ANALYSIS OF METAL MELTING METHODS: CASE STUDY OF LATVIA

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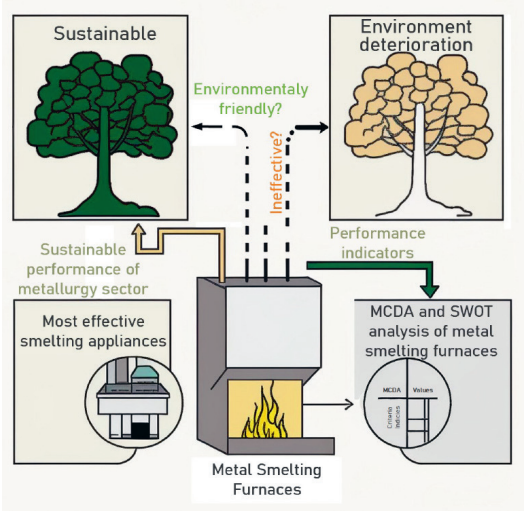
Abstract – Metal is one of the most used materials in the world. It was an important impetus in technological development during the industrial age and is still pushing us forward to this day. Along with the growth of metal consumption, the amount of scrap metal also increases. The correct use of this kind of waste plays an important role in reducing the negative impact of the metalworking industry on the environment. Replacing raw metal with scrap metal can reduce the amount of electricity consumed by up to 10 times and the amount of CO_2 emissions created by up to 30 times. The choice of the optimal scrap metal processing technology also plays an important role. The metal melting furnace can be considered the backbone of the industry, and the environmental indicators of the entire scrap metal melting process depend on its efficiency. In this paper, 8 metal melting furnaces are analysed according to 11 natural criteria. In addition, a SWOT analysis is carried out to determine the efficiency of the metal smelting process in Latvian metalworking enterprises and the possibility of expanding enterprises in the future.

Keywords – Emissions; Latvia; metallurgy; MCDA; scrap metal; smelting; SWOT



Acknowledgement

This work has been 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" of the Specific Objective 8.2.2 "To Strengthen Academic Staff of Higher Education Institutions in Strategic Specialization Areas" of the Operational Programme "Growth and Employment".

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MSW MANAGEMENT IN MOUNTAINOUS AREAS: OUTCOMES FROM A COMPARISON BETWEEN TWO ITALIAN PROVINCES

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Abstract – In the present paper, two case studies are reported regarding the municipal solid waste (MSW) management trend in the last decades in two Italian areas in order to propose some guidelines for replicating the approaches. *The first case study* has a very good selective collection (SC) rate that is expected to reach 80 % in a few years. SC is made mainly kerbside. There is no thermo-chemical plant in the territory (but a part of the residual MSW is burnt in an external combustion plant). A local plant combines anaerobic digestion with post-composting as a main destination for food waste and green waste. A sanitary landfill receives the main stream of locally pre-treated residual MSW. The adopted tariff helped increasing the SC rate: since 2013, the punctual tariff has been adopted. *The second case study* concerns an area where SC reached about 75 % in 2019, before the pandemic period that affected the performances of the sector. The punctual tariff has been recently introduced. In the territory, there are an incineration plant and a Solid Recovered Fuel (SRF) plant that sends the final product mainly to a cement factory. No plant for the biodegradable waste exists locally (export is adopted). Looking at the two case-studies, useful waste guidelines for similar areas could be set up starting from these experiences.

Keywords – Circular economy; guidelines; mountainous area; municipal solid waste; waste management

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MUNICIPAL SOLID WASTE MANAGEMENT TOWARDS CLIMATE NEUTRALITY

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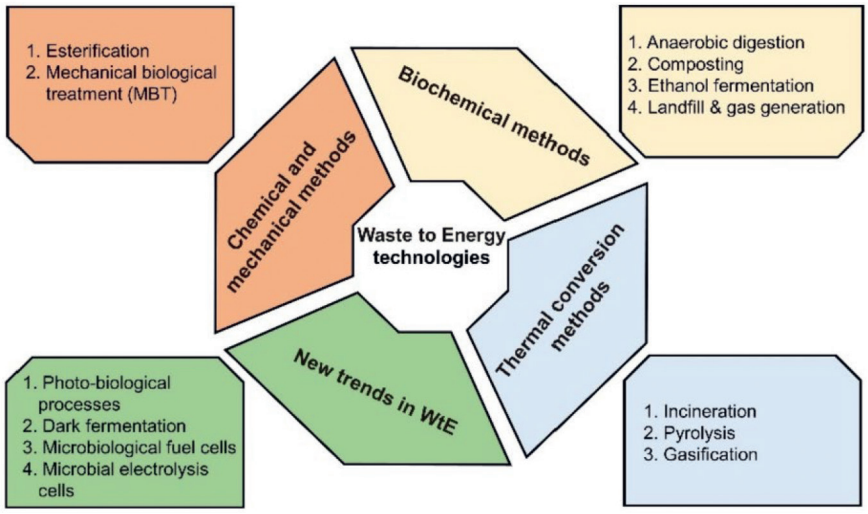
Abstract – In line with the European Union's move and the Green Deal initiative, Latvia needs to reduce CO_2 emissions by 2030 and reach their complete elimination by 2050. Since waste management sector is associated with high greenhouse gas emissions, the sector will experience changes in the near future, and its sustainable development is linked to overcoming technical, economic and environmental challenges. The work aims to find solutions to the development of the waste sector in an environmentally sound manner, ensuring that the sector is closer to climate neutrality in 2050. Waste management is at the forefront of major changes and challenges in achieving regulatory objectives. In view of the changes expected and taking place in the sector, it is essential to carry out studies on resource and material recovery optimization options and potential for waste streams to be recycled and the energy recovery potential for non-recyclable streams. Acquiring knowledge and raising awareness of the role of changing management practices in saving CO_2 emissions – avoided emissions – will allow the sector to move towards climate neutrality. This article analyses biodegradable waste management options and proposes the optimal solution for biodegradable waste management towards climate neutrality.

Keywords – Biodegradable waste; percolate; tunnels; waste to energy



Technological options for waste management.

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ORIGINS OF THE CONCEPT OF CIRCULAR ECONOMY AND ITS EVOLUTION

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Abstract – The first concepts connected with the material circularity have been introduced through the terms of Industrial Symbiosis and Industrial Ecology since the 1940s. In 1947 Renner, G. included in his works the term of 'reuse – exchange' as processes by which waste or by-products of an industry or industrial processes become the raw materials for another one (exchange). In 1966, Economy in Washington – with the paper 'The Economics of the Coming Spaceship Earth' presented the idea of a circular loop for the materials, considering open and closed systems. Moreover, in the 1970s, Stahel, W. R. introduced the concept with the expression 'cradle-to-cradle' in opposition with 'cradle-to grave'. As a consequence of the environmental revolution, the industrial ecology gained more and more importance. In the 1980s, Frosh, R. A. proposed an analogy of natural ecosystems, for the eco-industrial ones: in addition to reducing the production of wastes, they should maximize the efficient use of residue materials and end-of-life products, as an input for other production processes. In 1994, Pauli, G. in 'Zero Emissions Research and Initiatives' divided the economic models in three: red, green and blue economy. Later, Ayres went ahead using the metaphor of the biosphere (ecology) – technosphere (economy), followed by Biomimicry of Benyus, thanks to the 'Spiral of Life'. At the end of the 19th and the beginning of the 20th centuries, the Linear Economy based on the terms take, make, consume, throw away was introduced. Its development is connected with the technological innovations encouraged by the growing scientific development increased productivity and promoted the progress of the linear economy. The Circular Economy, was introduced in 2015 by the European Union, and its aim is connected with the concept of: a) more efficient and sustainable use of resources; b) new integrated model of production, distribution and consumption.

Keywords – Circular economy; environment; evolution, sustainability; waste management

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SAND PARTIAL AND FULL REPLACEMENT IN CONCRETE COMPOSITE WITH RUBBER CRUMBS

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Abstract – The objective of the research on rubberized concrete that substitutes sand fillers with rubber crumbs by volume or weight is to identify ways to utilize discarded rubber tires and improve the building industry's sustainability. The research indicates that substituting sand fillers with rubber crumbs can have a substantial effect on the concrete's physical and mechanical qualities. Significant decreases in flexural strength and compressive strength are observed when 100 % of the sand is replaced with rubber crumbs, showing that the attributes of rubber concrete are weaker than those of conventional concrete. Note that the precise mix design and proportion of rubber crumb replacement will alter the qualities of rubber concrete. Therefore, it is essential to conduct proper laboratory testing and trial mixing in order to optimize the mix design and determine the replacement % that would deliver the needed qualities and match the standards. The flexural strength of the reference sample was 2.7 MPa and its compressive strength was 57.7 MPa, compared to the compressive strength of the sample in which 100 % of the sand was replaced with rubber crumbs. The flexural strength of sr100 was 0.39 MPa and its compressive strength was 4.4 MPa. It is also important to note that rubberized concrete may still have some advantages over ordinary concrete, such as enhanced sound insulation, thermal insulation, and chloride ion penetration resistance. These characteristics may make it useful for applications including sound barriers, underground constructions, and marine structures.

Keywords – Concrete composite; rubber crumbs; substitutes sand filler; utilize discarded rubber

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SOCIAL ASSESSMENT OF HEALTHCARE WASTE MANAGEMENT

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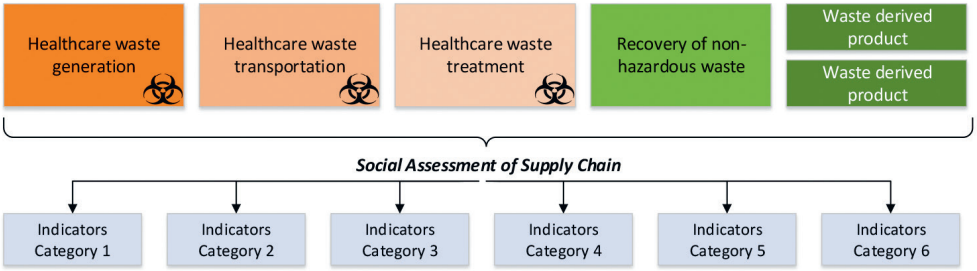
Abstract – Circular economy targets clearly define recovery and recycling as predominant actions for future waste management. However, circularity-oriented actions might not be easily implemented for some types of waste. Healthcare sectors generate non-hazardous municipal waste (up to 80–85 % of all generated waste according to the World Health Organization data) and hazardous infectious waste. Due to public health and the spread of infection risks, healthcare waste treatment needs to be organized in a special manner and moreover, recovered materials need to be tested repeatedly. The present paper aims to analyse the social aspects of health care waste recovery technologies along the supply chain (gate-to-gate approach) – from health care waste collection at medical care institutions to recovered materials at treatment plants. Rotoclave and chemical treatment healthcare waste treatment technologies were analysed as case studies. Methodological approach of the study is based on the UNEP/SETAC guidelines for social life-cycle assessment (S-LCA) of products and questionnaire-based indicators. The results of the assessment will bring the framework for improvement of social aspects of healthcare waste management.

Keywords – Circularity; indicator analysis; infectious waste; medical waste; social life cycle assessment



Social assessment framework of the healthcare waste management.

Acknowledgement

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SOUND INSERTION LOSS PERFORMANCE OF BAFFLES WITH DEVULCANIZED WASTE RUBBER

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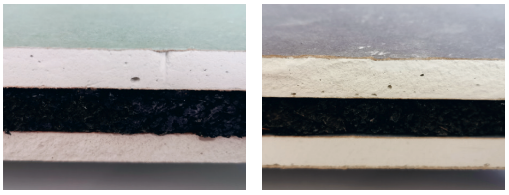
Abstract – In this study, the insertion loss of devulcanized waste rubber baffles was evaluated. Acoustic baffles are suitable for reducing noise from the devices or machines by interfering with their emitting sound waves. Knowledge of the acoustic properties of the material used is of significant importance in ensuring the effectiveness of the acoustic properties of the baffle. Basic properties include airborne sound insulation, which is usually determined during laboratory testing. Baffle consists of sound absorbing and sound insulating materials. In this study, plasterboards were used as sound insulating material and devulcanized waste rubber as sound absorbing material. Devulcanization targets mostly the scission of sulphur crosslinks. Devulcanization techniques that have been explored in rubber recycling include thermos-chemical, microbiological, ultrasonic microwave thermos-chemical devulcanization in a supercritical carbon dioxide medium ($scCO_2$). In this study, two types of rubber granules were devulcanized by grinding method and one other type was chemically devulcanized. Three types of rubber granules were mixed together in increasing 25 % proportion steps and glued with patented polyurethane glue. Total of 15 different composition devulcanized waste rubber granule boards were made. Rubber boards were attached together with the plasterboards. Insertion loss of the different composite baffles was measured in semi-anechoic chamber in a purposefully designed stand in 1/3rd-octave bands. The results showed that the insertion loss of the baffles depends mostly on the rubber granule board density. Increasing the density of the rubber board, insertion loss also increased. 5–6 dB insertion loss difference was measured between the most and the least dense rubber granule board baffles.

Keywords – Baffle; devulcanization; insertion loss; rubber; sound reduction

Semi anechoic chamber and insertion loss measurement stand.



Construction of baffles with devulcanized waste rubber.

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CIRCULAR ECONOMY OPTIONS FOR MEDICAL TEXTILE WASTE

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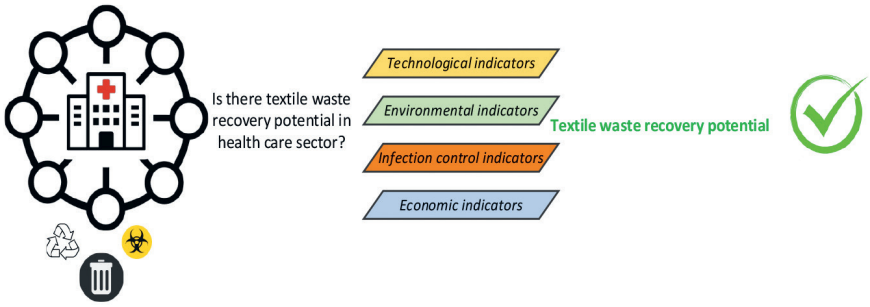
Abstract – To support circular economy and sustainability, all European Union Member states are obliged by 2025 to collect textiles separately. Textile waste has become a part of the Sustainable Development Goals that aims to innovation in the textile sector including textile collection, reuse, sorting and recycling. Along this, the healthcare industry has a significant impact on the environment: it releases annually around 26 Gt of CO_2 greenhouse gas emissions and generates on an average 3 kg of medical waste per bed per day in healthcare facilities in Europe. The main focus of the research paper is to quantify the material flow of textile waste generated/likely to be generated in the health care sector as well as to calculate its potential for material recovery. Since medical textile recovery has limitations in sorting and recycling activities due to prevalence of infections, a systematic approach in textile waste management needs to be applied both at collection phase and treatment phase. Within the present research, a database with health care products categories (42 units) are developed, and the categories are characterized by textile type, application in health care sector, fibre, contamination level after use, potential product for substitution. To measure the recovery potential of the textile waste, the indicator analysis considering technological, environmental, infection control, and economic aspects is performed.

Keywords – Circular economy; healthcare waste; indicator analysis; sustainability of fibre



Algorithm for the textile waste recovery potential in health care sector.

Acknowledgement

This research is funded by the Latvian Council of Science, project "Public health and environmental pollution prevention through circular economy approaches in health care waste management (Panacea)", project No. LZP-2020/1-0299.

07

ENVIRONMENTAL AND ENERGY POLICIES AND FRAMEWORKS

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ANALYSIS OF FRAMEWORKS FOR THE ASSESSMENT OF THE BUILDING STOCK DECARBONISATION IN EUROPE

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Abstract – The European Union (EU), aware that having an energy efficient building stock is crucial to achieve decarbonisation goals and to improve people's quality of life, has established a legislative framework made up of Energy Performance of Buildings Directive (EPBDs) and Energy Efficiency Directive (EEDs) to support Member States' (MS) governments in boosting energy performance of buildings by offering a broad range of policies and support measures. Since 2014, all EU countries must establish a long-term renovation strategy (LTRS) every three years to support the renovation of their national building stock into a highly energy efficient and decarbonised building stock by 2050, contributing to achieving the Member States' energy and climate plans (NECPs) targets. The requirement for EU countries to adopt a LTRS was first set out in the EED (2010/31/EU) and was revised in 2018 EPBD (2018/844/EU). With the aim of facilitating the interpretation of the latter directive by the national governments, Commission Recommendation (EU) 2019/786 was published. In this recommendation a voluntary framework based on progress indicators to assess the decarbonisation of the building stock was proposed. Later, in 2021, a proposal for the recast of the EPBD was launched, and in 2022 it was revised. In these new versions, the LTRs are strengthened towards building renovation plans (BRP). The plans will include national targets in a more unified and comparable approach, and progress will be measured through a compulsory assessment framework based on indicators, among other issues. In this paper, the assessment frameworks proposed in the Commission Recommendation (EU) 2019/786, the proposal for the EPBD recast (2021 version) and the proposal for the EPBD recast (2022 version) are compared. Additionally, 2020 Member States' LTRSs are analysed, focusing on the indicators that each one proposes to assess the renovation progress in the country. Finally, the level of alignment between the indicators proposed by each national strategy and by the 2022 proposal for the EPBD recast is evaluated in order to identify best practices among MSs to get closer to the future 'Building renovation plans'.

Keywords – Building renovation; building stock decarbonisation; European building stock; national renovation strategies; progress indicators

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ASSESSING THE EFFECTIVENESS OF ENERGY POLICY MEASURES TO ACHIEVE ENERGY DEPENDENCE AND ENERGY SECURITY

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Abstract – The publication examines what measures the European Union is currently taking in the energy sector to promote energy security and independence from fossil energy resources. Taking into account the geopolitical situation, the European Commission has launched REPower – a new action plan for Europe on how to save energy, diversify energy supply and use renewable energy resources while rapidly reducing dependence on Russian gas and oil imports. The publication examines which actions are prioritised in planning documents to promote energy security in the European Union and how they align with the priorities set out in Latvia's NECP to 2030. The indicator approach is used to identify which measures should be ranked higher and which measures need to be revised or improved. At the end, the conclusion is drawn whether the proposed measures will be sufficient to achieve energy security as the geopolitical situation changes.

Keywords – Energy independence; energy security; energy consumption; policy

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CLIMATE CHANGE: A MULTIPLIER FOR TERRORIST ACTIVITY

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Abstract – Over the past ten years, both understanding and awareness of the links between climate change and security have increased. However, those links are not simple and clear. The growing impacts of climate change do not automatically lead to more violence and conflict. Rather, climate change acts as a threat multiplier. The study addresses the question of how the impacts of climate change are a contributing factor in the rise and growth of terrorism and political violence in African regions. To explain the complexity of the problem, a system dynamics model structure is presented in the form of casual loop diagrams. The dynamic behavior in livelihood arises from negative impacts of climate change on livelihoods in many countries and regions through, e.g. water and land scarcity, food insecurity and migration. The affected population groups are becoming more vulnerable not only to negative climate developments but also to recruitments by violent groups such as Al-Qaeda, Islamic State, Al-Shabaab or other militia. These terrorist groups can offer alternative livelihoods, economic motivations, and responses to possible political and economic dissatisfactions. This does not imply that there is a direct link between climate change and terrorists-related violence and conflict. However, environmental impacts and climatic change contributes to creating conditions in which these groups can thrive and facilitate the pursuit of their strategies. Further, violent groups are using natural resources as a weapon of war. In fragile environments, these groups can use water resources as a weapon or reduce access to natural resources. This development creates a dynamic for these groups, considering the fact that the scarcer resources become, the more power is given to those who controls them. Climate change will increasingly challenge the states' abilities to provide services and stability. In particular, extreme climate events can threaten the relationship between governments and populations. In such a case, a poor and slow government response could contribute to further instability, fragility, violence and strengthening of violent groups.

Keywords – Climate change; contributing factor; growth of terrorism; poor government's response; causal loop diagrams; system dynamics

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COMMON AGRICULTURAL POLICY IN LATVIA: SUSTAINABILITY ASSESSMENT

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Abstract – Sustainability has become an increasingly important factor in policymaking and investment planning due to environmental, economic, and social concerns. To achieve sustainable development objectives, decision-makers must implement policies encouraging environmentally responsible activities such as enacting laws and regulations, investing in green infrastructure, and encouraging research of new technologies. Furthermore, sustainable investments are essential for the environment and socio-economic development, as they can create jobs, improve livelihoods, and reduce poverty rates. European Union (EU) and its Common Agricultural Policy (CAP) is one of oldest and major policies of block. € 387 billion in funding has been allocated to the CAP for the period from 2021 to 2027, or roughly 30 % of EU budget for the period. Latvian national plan for the period 2021–2027 is € 2.5 billion. It is necessary to find correlation between financing and sustainability and how to assess CAP sustainability. Therefore, a study researching the connection between the funds available under European Union's CAP (Latvian case study) and United Nations sustainability goals is performed using quantitative analysis to evaluate how it promotes implementation of sustainability goals. The research has found that approximately 15 % of CAP will be dedicated to environmental sustainability, while 85 % will be dedicated to social sustainability. Only very few targets are not falling under any UN sustainability goal. The most spread and financially supported UN goal is 'Decent Work and Economic Growth' (65 %), followed by goal 'Climate action' (15 %). To mitigate the harm to the environment, vertical targets and directions become more environmentally related over years, and specific and proactively available financing tend to be more focused on the environment. The study shows that CAP is sustainable from the UN sustainability perspective. CAP is a dominantly social and business-related program (85 % of activities and financing). From total activities, 15 % are environmentally related. Further research is needed on what would be the best social and environmental division. Results show that policies sustainability can be analysed and quantified using UN Sustainability goals. Research results can be used to analyse other national CAPs in EU.

Keywords – Agriculture; common agricultural policy, environment; European Union; financing; sustainability; United Nations

https://doi.org/10.7250/CONECT.2023.119

EVALUATING THE EFFECTIVENESS OF AGRICULTURAL AND FORESTRY POLICIES IN ACHIEVING ENVIRONMENTAL GOALS THROUGH ENVIRONMENTAL POLICY DOCUMENTS

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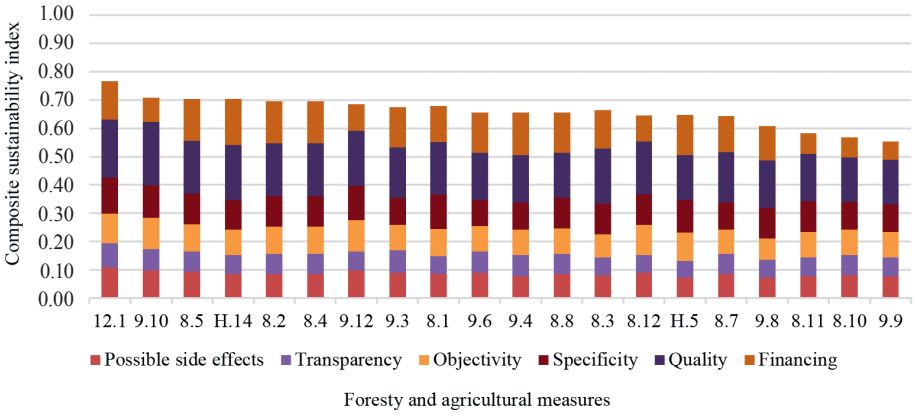
Abstract – To achieve the set climate targets by 2030 and become climate neutral by 2050, each Member State must develop a National Energy and Climate Plan (hereinafter – NECP) that contains practical and effective measures to achieve the targets set. The effectiveness of the agricultural and forestry measures defined in the Latvian NECP was assessed through the definition of appropriate indicators, an expert survey, and a composite sustainability index. The linkage between the measures or action lines in the Latvian NECP related to agriculture and forestry, the European Green Deal measures and the objectives of the European Union Bioeconomy Strategy was assessed. The results show that the effectiveness of agricultural and forestry measures is most influenced by factors such as quality, financing, and specificity. The description of the measures should be more detailed, with specific activities, indicators to be achieved, and amounts and funding sources planned for each activity. The lowest scoring measures are specific measures whose impacts cannot be measured and are not explicitly mentioned as relevant in the European Bioeconomy Strategy, the European Green Deal.

Keywords – Bioeconomy; composite sustainability index; effectiveness of policy measures; environmental policy documents; forestry and agricultural policies



Composite sustainability index of agriculture.

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HOW TO MEASURE PUBLIC AWARENESS OF ENVIRONMENTAL PROTECTION

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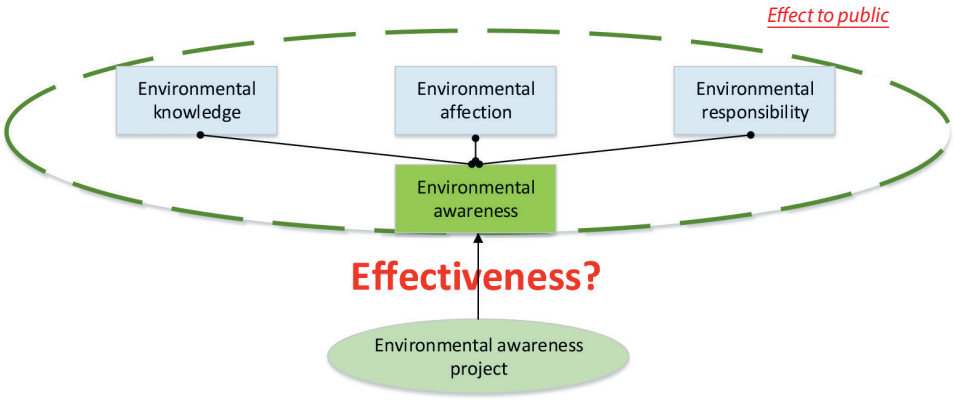
Abstract – Human actions intensified processes in the environment, such as climate change, loss of biodiversity and environmental pollution, escalating the role of environmental awareness. Along with the formal environmental education performed in pre-schools, schools and universities, vocational education is taking a special role due to the flexibility of educational formats as well as the diversity and deepness of topics to be covered. While there are a lot of public awareness campaigns on climate change, environmental and nature protection issues, there is still a lack of methods on how to measure the effectiveness of these. Within the present paper, the methodology for measuring the effectiveness of outdoor events focused on awareness raising of local society on nature protection actions. The methodological framework is based on the ecosystems services travel cost method – estimation of the value of nature provided benefits generated by ecosystems. As a case study object to adapt the methodology, a project named Nature Concert Hall is selected. Nature Concert Hall is a symbiosis of science, music, poetry and visual art organising annual summer festivals (1–2 per year) in previously unrecognized natural settings, such as meadow, forest, seacoast or riverside but dedicated to a specific nature protection topic. The effectiveness of the event is measured for the period of 7 years.

Keywords – Ecosystems services; environmental education; nature protection; public participation; sustainability



Insight into a methodology for measuring environmental awareness.

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IDENTIFICATION OF THE WEAK STAGES OF THE AGRICULTURAL SECTOR'S PROGRESS TOWARD CLIMATE NEUTRALITY

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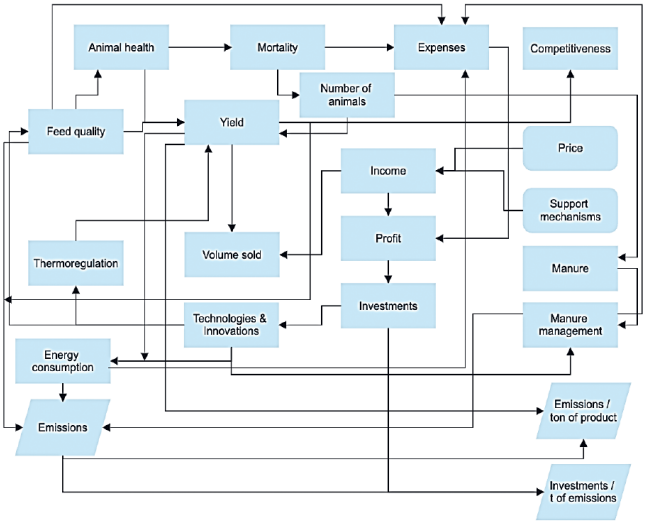
Abstract – The agricultural sector's progress towards climate neutrality is of great importance not only in the climate but also in the economic and social context. The agricultural sector is the 3rd largest emission-generating sector both in Latvia and Europe, and it directly and/or indirectly affects all other sectors. Climate-neutral agriculture is highly dependent on innovations that ensure maximally efficient farming, which does not only reduce emissions, but also ensures competitiveness in the market. However, all of this is fundamentally influenced by well considerate policies. Although the goals of the Green Deal are united, each country's situation must be thoughtfully considered individually to evaluate the best action plan for integrating the EU's common agricultural policy. In addition, due to the complicated structure of the sector, it tends to be very difficult or even impossible to determine the real obstacles and mistakes that delay the progress of sustainable farming. Therefore, this research aims to create a system dynamics model using Latvia as a case study, which would not only provide an insight into the system's structure but also identify the system's weak links and allow for the development of recommendations. The results could help policymakers in any country to make rational, non-controversial decisions simultaneously in the context of economic and Green Deal objectives. The results of the study demonstrate that in order to increase economic competitiveness and reduce emissions in agriculture, the most important aspect is the ability to invest in innovations and new technologies that would achieve not only the lowest emissions, but also the highest productivity and competitiveness in the market.

Keywords – Agriculture; climate neutrality; GHG emissions; innovations; policy; system dynamics; sustainability



Simplified agricultural (dairy) enterprise scheme.

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SENTIMENT ANALYSIS IN ENVIRONMENTAL SUSTAINABILITY FIELD BY MACHINE LEARNING

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Abstract – Environmental sustainability is one of the influential topics of the last decade. Most people have become more environmentally aware and educated environmentally conscious. Sustainability concerns the sustainability of natural resources and environmental protection. The four pillars of sustainability include human, social, economic and environmental. Twitter is a popular social media platform that keeps us updated on the latest news, events and trends from around the world. In 2022, the number of Twitter users in Thailand reached around 11.45 million, accounting for 16.4 % of all Thai people. Also, the fastest growing conversation in Twitter is related to the environment and sustainability. Nowadays, customers pay attention to the environmental and social impact of products they buy. Sentiment Analysis is the process of analyzing emotions or feelings by using machine learning techniques. The main objective of this exploratory study is to conduct social media opinion mining in case of the environmental sustainability field of Thai people. The paper presents the linguistic analysis of the collected data and explains discovered phenomena, including data preprocessing steps, feature extraction, and model construction to determine positive, negative and neutral sentiments. The result reveals that sentiment analysis takes place around the sustainability context mostly in positive terms to make a better understanding of the dynamics and changes in environmental sustainability society.

Keywords – Awareness; environmental sustainability; environmental protection; machine learning; sentiment analysis

Acknowledgement

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THE AGRICULTURAL SECTOR TOWARDS CLIMATE NEUTRALITY

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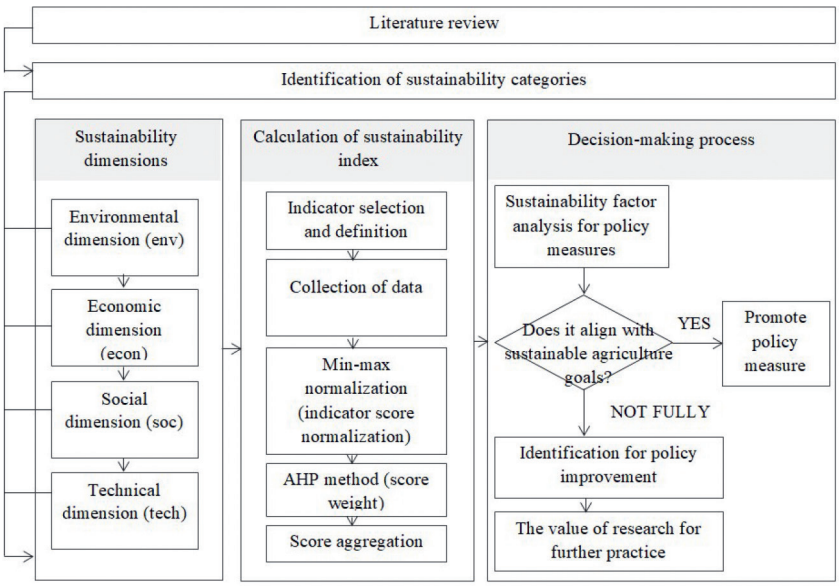
Abstract – Agriculture is one of the leading sectors which significantly contribute to the increase of GHG emissions, thus contributing to the negative impact that climate change can cause on biodiversity and create extreme weather changes, raise the sea levels, revers ocean currents etc. One of the main objectives of the new Common Agricultural Policy (CAP) is to improve and promote the sustainability of rural regions by providing economic support and direct payments to ensure farmers' incomes, which can be compared with the level of other sectors. Direct payments are not only a way to reward farmers but also an opportunity to generate income for farmers in an environmentally friendly operation, providing compensation for possible losses due to reduced production intensity or for costs incurred by farmers in applying climate and environmentally-friendly practices. However, the mechanisms used in the CAP – direct payments and subsidies – do not significantly increase agriculture's sustainability and technological efficiency. Using a results-based scheme, it is possible to see more clearly the relationship between payment and biodiversity achievements; farmers are defined with specific results that must be achieved. Still, no specific actions are being taken taken to arrive at the results. In this article, the analysis based on a sustainability assessment of CAP measures is performed and blind spots are identified.

Keywords – Carbon farming; common agricultural policy; measures; sustainable carbon cycles



Sustainability index calculation for methodology.

08

ENVIRONMENT, HEALTH, POLLUTION PREVENTION

https://doi.org/10.7250/CONECT.2023.124

APPLICATION OF *CITEROMYCES SIAMENSIS* FOR MOLASSES WASTEWATER DECOLORIZATION

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Abstract – Molasses is a brownish black viscous liquid produced in the last step of the cane sugar separating process. Molasses can be used in many industries, such as fertilizer production, animal husbandry, alcohol production, monosodium glutamate production, and acetic acid making. In Thailand, it is mainly used to produce alcohol and as animal feed. Molasses waste water is high in biochemical and chemical oxygen demand and suspended solids. If released into the environment without treatment, it will cause many environmental problems. Moreover, the molasses wastewater contains melanodin that is difficult to remove, which gives it a dark colour. The treated water, therefore, has a dark colour. If the treated water is released into a natural water source, it will cause the water to have an unusually dark colour. This research aims to study the optimum conditions for using *Citeromyces siamensis* microorganisms for biological disposal of wastewater. The experiment was conducted to find conditions that promote the reduction of the colour of molasses in wastewater. It has been found that the addition of 1 % glucose and 1 % peptone is more effective in decolourization by *Citeromyces siamensis* than the addition of other nutrients.

Keywords – Citeromyces siamensis; decolorization; molasses; wastewater

Acknowledgement

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ASSESSING THE GLOBAL SUSTAINABILITY IMPACT OF IMPROVING THE SECONDARY STEEL PRODUCTION: LESSONS LEARNED FROM AN ITALIAN STEEL PLANT

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Abstract – This study presents a comprehensive sustainability assessment of a series of technical interventions aimed at improving a secondary steel production process using the Electric Arc Furnace (EAF) technology in a steel plant located in northern Italy. The assessment covers the environmental, social, and economic dimensions of sustainability by considering three sets of indicators and employing a multi-criteria decision-making approach. The results show that the considered interventions can lead to significant improvements in the sustainability performance of the EAF process. The study also highlights the trade-offs and synergies among the sustainability dimensions and provides recommendations for decision-makers to promote sustainable practices in the steel industry. Overall, this study underscores the importance of addressing the sustainability challenges faced by energy-intensive industries such as steel production.

Keywords – Electric Arc Furnace; life cycle sustainability assessment; multi-criteria decision-making; steel production

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SUSTAINABLE TECHNOLOGY OF WOOD CHARCOAL DIFFUSER FOR INDOOR ACOUSTICAL QUALITY

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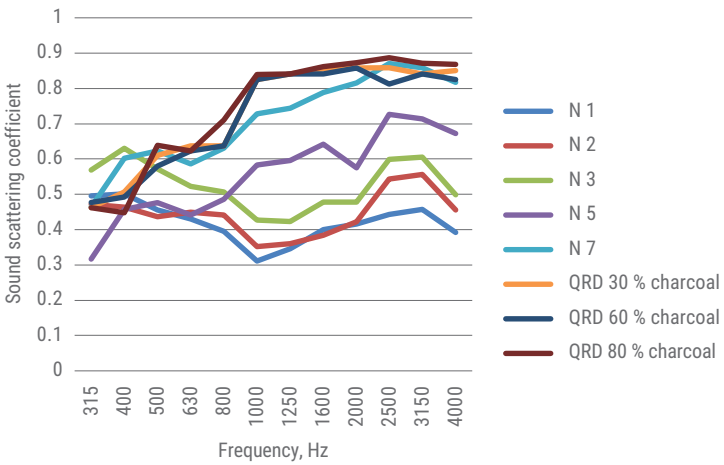
Abstract – Wood charcoal is sustainable, renewable, environmentally friendly material using which the acoustic device may be produced. Charcoal made of wood waste materials allows to improve indoor acoustical quality. The current article aims to investigate sound scattering coefficients of quadratic residue diffusers with the covering of oak (*Quercus robur*) wood charcoal elements. The sound scattering coefficient is calculated due to the reverberation time measurement in the reverberation chamber. The calculation results of the scattering coefficient show the growth of scattering in the frequencies – the highest value reached 0.88 (diffuser N7 with charcoal). The effectiveness of diffusers to diffuse sound waves increases as the number of wells grows. The diffuser with 80 % charcoal elements showed a higher scattering coefficient comparing to the diffuser without charcoal elements.

Keywords – Diffuser; renewable materials; sound scattering coefficient; wood waste; wood charcoal



Sound scattering coefficient of diffusers with covering of oak charcoal elements.

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RELATIONSHIP BETWEEN GREENNESS AND HEALTH INDICATORS IN URBAN PATIENTS WITH HEART FAILURE

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Abstract – The environment has a significant impact on a person's general well-being. Distance to green space has been found to be an important factor influencing health. Urban green spaces enhance people's quality of life and physical and mental health. According to recent research, living near green space may reduce one's risk of developing cancer, cardiovascular and respiratory diseases, as well as other harmful health issues. In this study, the health data was collected in 2007–2009 in Kaunas, Lithuania. The study participants (144) randomly were divided into two groups, control, and trained groups. Long-term aerobic physical training was applied to the exposure group. General clinical, echocardiography, and spiroergometry parameters were evaluated for the study participants. Greenness was estimated from satellite-derived normalized difference vegetation index (NDVI) in zones with radii of 1 km, 1.5 km, and 2 km surrounding the participants' residences. To assess the effect of greenness on the effects of rehabilitation, changes in health indicators during a period of 6 months in the groups of low/high greenness environment were presented separately for participants in control and training group. For this purpose, the paired t-test was used. For changes in patient characteristics, the effect of greenness within a radius of 1.5 km was stronger, also the effect within a radius of 1 km was similar. It was discovered that in the trained group, people who lived in high greenness experienced the best increases in the distance walked over the course of six minutes (6 MWT) and a decrease in the mean heart rate. Spiroergometry indication improvements were notable and more pronounced for residents of high greenness areas. After 6 months, a decrease in echocardiographic indicators was found when living in low greenness. Living in low greenness was found to raise diastolic blood pressure and reduce 6 MWT in the control group. Only the control group's ejection fraction was non-significant alterations in the low greenness environment. It can be concluded that greater greenness, according to NDVI, may lead to better rehabilitation outcomes for heart failure patients undergoing an aerobic exercise training program.

Keywords –Greenness; health indicators; heart failure; patients

https://doi.org/10.7250/CONECT.2023.128

THE EFFECT OF LASER ON THE EFFICIENCY OF BIOLOGICAL TREATMENT OF PHARMACEUTICAL WASTEWATER

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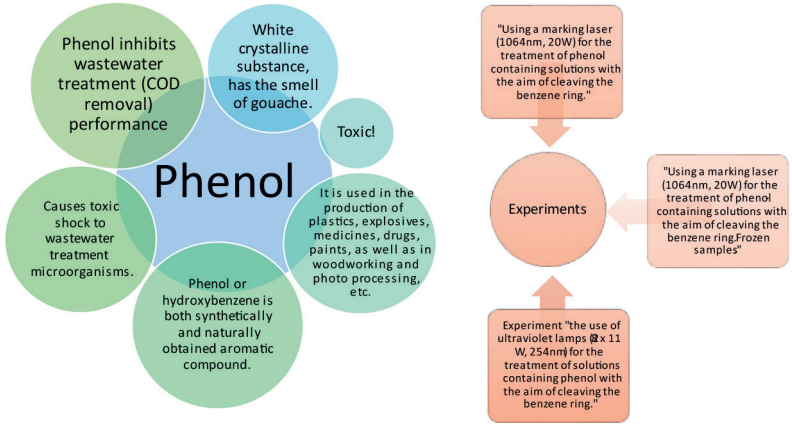
Abstract – The aim of the work is to explain the danger of phenol and phenolic compounds to human health and the environment. In addition, it explains where and why pollution by phenol and its compounds occurs, especially in industrial wastewater. The authors investigate the possibility of using laser technologies for the decomposition of phenol, as well as for the purification of industrial wastewater from phenolic compounds. Treatment of wastewater from phenol and its compounds using microorganisms for biological treatment is widely used in the world. This method is economical and environmentally friendly. On the other hand, exceeding the permissible concentration of phenol, which is individual for each biological treatment plant, microorganisms in such treatment plants may die because they are poisoned by phenol or its compounds. Thus, the biological treatment of industrial wastewater is temporarily stopped until the concentration of phenol is reduced to an acceptable limit and the microorganisms recover. Such a procedure can take a long time and is unpredictable because microorganisms are sensitive to changing conditions. Based on this, literature sources have been explored. This could help to understand which laser devices can be used to split a phenol compound or a benzene ring into simple chemicals. It also helps to understand how phenol-containing wastewater affects the microorganisms of biological treatment plants and the course of the process, as well as to find a laser device that would not affect the usual conditions of microorganisms of biological treatment plants. Several experiments were carried out, including those with lasers, to exclude possible interfering factors and to prove the already known data for further scientific research.

Keywords – Biological wastewater treatment; laser technology; phenol



Phenol characteristics and experiments description.

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TREATMENT OF TEXTILE WASTEWATER CONTAINING DYES

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Abstract – In recent years there has been an interest in the study of new methods for the removal of textile dyes from water due to its large-scale use in different industries. For example, paper printing, textile, leather, pharmaceutical, food or technological applications. It is estimated that more than 700 thousand tons of about 10 000 different types of dyes are produced annually. Most of them are of synthetic origin and can generate adverse effects, for example, teratogenic, mutagenic and carcinogenic action. Dyes are mainly applied in the textile industry, and they are usually classified into anionic (acid dyes), cationic (basic dyes) and non-ionic (disperse dyes) dyes. The direct discharge of dyes into the environment can cause various damages to plants and animals: dyes can block the penetration of sunlight, reduce the photosynthetic efficiency of aquatic plants and ultimately destroy the ecological balance of the aquatic ecosystem. This study determines the adsorption efficiency of congo red, methylene blue, rhodamine B and naphthol green B dyes used in textile industry by using the aerogel. To achieve the aim, the effects of adsorbent dosage, pH, dyes concentration, adsorption contact time and temperature of solutions were studied. Kinetic data, equilibrium isotherms and thermodynamic parameters were determined.

Keywords – Circular economy; textile dyes; sorption; wastewater treatment

09

WASTE TO PRODUCT,
VALUE ADDED PRODUCTS

https://doi.org/10.7250/CONECT.2023.130

EXPERIMENTAL EVALUATION OF CARRIER MATERIALS: A NEW WOOD ASH FILTER MATERIAL COMPARISON WITH OTHERS USED FOR EX-SITU BIOMETHANATION

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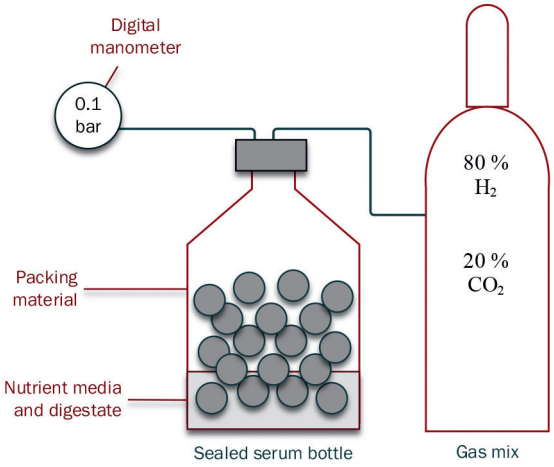
Abstract – Biomethanation is a prospective method to integrate a renewable solar or wind power grid with a biogas grid, where excess energy can be used to produce hydrogen for the biomethanation of the biogas and produce biomethane. The use of biotrickling filter reactors with appropriate carrier materials for biomethanation is essential for the immobilisation of hydrogenotrophic methanogens on the surface of the packing material. Wood ash filter material use end-of-the-line waste ash as the main raw material for the production of filters. The wood ash filter material is a robust porous material that has good properties in the context of biomethanation. Testing packing materials in constantly operating biotrickling filter reactors would cost too much time and money. The purpose of this study is to compare a novel wood ash filter material with materials that are often applied in the sector. The study uses an effective methodology to test three alternative packing materials for use in a biotrickling filter. The manometric method and BMP test is used to determine the rate of CH4 production. The physical parameters such as bulk-specific surface area ($m^2 \times m^{-3}$), external porosity (% vol), and bulk density ($kg \times m^{-3}$), and chemical composition of the novel wood ash filter material are compared to other filter materials commonly used in biomethanation applications. The results of the experiment determine whether the novel wood ash filter material or other tested materials can compete with and even replace some of the materials currently used in biomethanation applications.

Keywords – Biogas upgrading; biomethanation; biotrickling filter; carrier materials; filter material; methanogenesis; reactor; wood ash



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EXTRACTION OF APPLE POMACE FROM JUICE PRODUCTION USING SUPERCRITICAL CO_2 EXTRACTION

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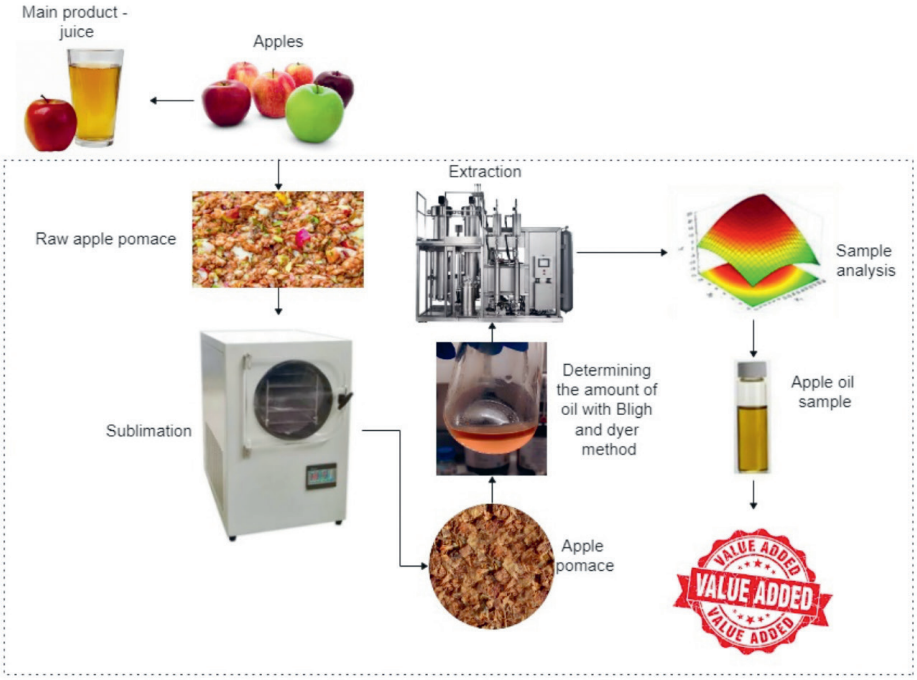
Abstract – Apple pomace, a by-product of apple juice and cider production, is a sustainable raw material from which valuable products such as nutritional supplements and pectin can be obtained. It contains significant amounts of antioxidant compounds that have been linked to several health benefits. Both traditional and new technologies can be used to extract valuable components from apple pomace, with an emphasis on new and environmentally friendly methods. One such technique is the use of supercritical CO_2 extraction. This method is considered environmentally friendly, and it can be used to extract valuable compounds such as antioxidants and pectin from apple pomace. This article examines the extraction parameters of apple pomace and analyses the valuable substances in the extract samples. Apple pomace is a promising source of carbohydrates, proteins, amino acids, fatty acids, phenolic compounds, vitamins, and other compounds with a vast range of food applications.

Keywords – Added value products; agriculture; apple pomace; by-products; extraction



Pathway of apple by-products to apple oil using supercritical CO_2 extraction method.

https://doi.org/10.7250/CONECT.2023.132

EXTRACTION OF QUINCE POMACE FROM WINE PRODUCTION USING SUPERCRITICAL CO_2 EXTRACTION

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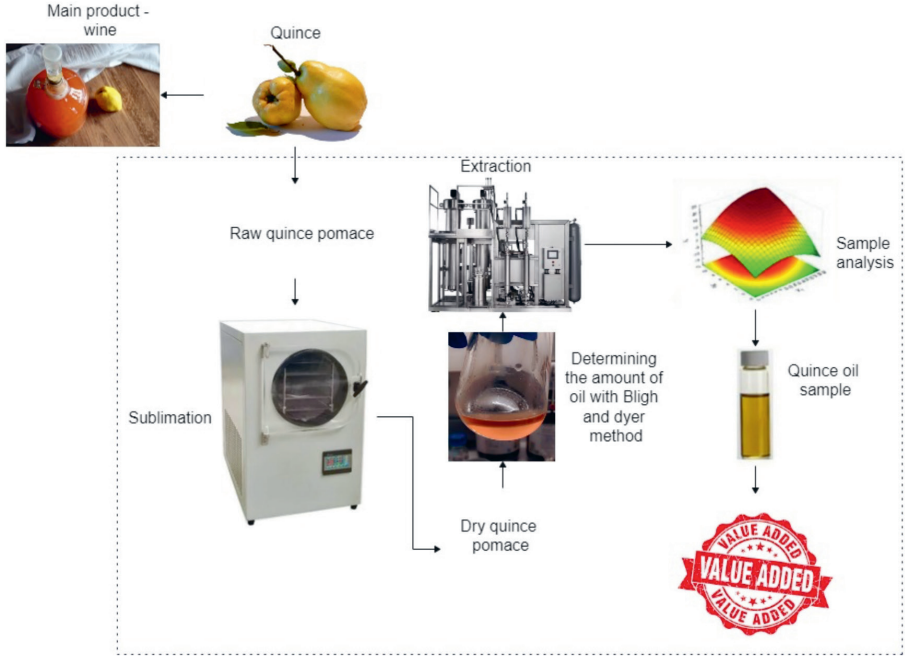
Abstract – The food processing industry generates a large amount of residues, which can be a sustainable and rich source of bioactive compounds. Extracting these compounds using traditional methods can be expensive and use large amounts of toxic and hazardous organic solvents. Supercritical CO_2 extraction is an environmentally friendly method for extracting bioactive compounds from industrial residues such as quince pomace. This method uses supercritical CO_2, which is the state of CO_2 when it reaches critical temperature and pressure, to extract compounds from the sample matrix. This method is considered 'green' because it does not use toxic or hazardous organic solvents and does not cause pollution. Quince pomace is a by-product of the winemaking process and can be used to produce new products that can be incorporated into nutritional, pharmaceutical and cosmetic formulations. Therefore, the authors investigated the extraction of quince pomace using the supercritical CO_2 method and analyzed the obtained samples. Overall, quince peel can be upcycled into fiber-rich and bioactive ingredients to endow the value chain with natural food fortifiers, preservatives, and health promoters.

Keywords – Added value products; agriculture; by-products; extraction; quince pomace



Pathway of quince by-products to apple oil using supercritical CO_2 extraction method.

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THE SYNERGIC EFFECTS OF NANO ADDITIVES ON THE MECHANICAL PROPERTIES OF GREEN LIGHTWEIGHT CONCRETE

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Abstract – Concrete materials have been commonly used in building and construction industries. However, the process of cement manufacture has long been connected with high consumption of energy and adverse environmental impacts. In this study, in order to produce innovative green concrete material that consumes lower energy, resources and is more eco-friendly, industrial waste by-product fly ash cenosphere has been utilized as lightweight aggregate to replace cement by 73.3 %. In most conducted researches regarding lightweight concrete (LWC) with cenospheres, attempts have been made to improve its physicomechanical properties by the inclusion of fibre materials, while limited studies have been performed to investigate the effects of nano additives, especially the synergic influence of them. Therefore, carbon nanotubes (CNTs) with the dosage of 0.05 %, 0.15 %, 0.45 % and nano silica (NS) with the content of 0.2 %, 0.6 %, 1.0 % by cement weight were used in this study as reinforcing fillers on the LWC. Experiments including flexural strength test, compressive strength test, water absorption and thermogravimetric analysis were carried out to evaluate the mechanical behaviors and the hydration characteristics of the produced LWC. Based on the experimental outcomes, the incorporation of CNTs and NS can effectively enhance both the flexural and compressive strength and reduce the absorbed water weight. The results from the thermogravimetric analysis reveal that the binary presence of CNTs and NS exerts positive impacts on the cement hydration reaction.

Keywords – Carbon nanotubes; compressive strength; fly ash cenospheres; flexural strength; nano silica; thermogravimetric analysis; water absorption

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UTILIZING MANUFACTURING WASTE BY DEVELOPING NEW BIO-BASED BUILDING MATERIALS

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Abstract – In the last decade, more research has been concentrated on reducing the usage of natural resources and waste management in construction building materials. There are many possibilities for reducing the waste from this sector, ranging from waste being used as filler materials to developing new binders and building materials. This research concentrates on bio-based building material development from wood-wool cement board manufacturing waste. The authors have found that a new bio-based building material can be produced using manufacturing waste. Two fractions of waste were used in this study. One fraction was the wood wool fibers mixed with cement that have fallen off the manufacturing chain and thus cannot be used to make wood-wool cement boards. This fraction was used as the filler material. The second fraction was the dust fraction in the quality assessment phase, where the wood-wool cement boards are sanded for better surface quality. This fraction is then vacuumed out of the manufacturing plant to avoid air pollution from the dust particles. The dust fraction contains wood wool fibers and hydrated and unhydrated cement particles. The cement particles are conglomerated when the mixing process of water, cement and wood fibers occurs. The hydrated cement particles stick around the unhydrated cement particles, encapsulating them. This results in not all the cement used to manufacture wood-wool cement boards. These conglomerates, however, can be broken down with a milling process and can hydrate once the water has been added. The binder with the filler material was used to develop bio-based building materials. The developed materials were tested for their apparent density, compressive strength, and thermal conductivity coefficient. The obtained results showed promising data for self-bearing bio-based building materials to be similar to other bio-based materials for their thermal properties and use as thermal insulation materials. The apparent density of the developed bio-based composites was 384–555 kg/m^3. The conclusion was made that by using waste materials for the production of bio-based building materials, it is possible to reduce the overall waste of the manufacturing plant and increase the sustainability aspect of wood-cement board manufacturers.

Keywords – Concrete composite; rubber crumbs; substitutes sand filler; utilize discarded rubber

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