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Energy, Bioeconomy, Climate Changes and Environment Nexus

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Abstract – **Overview of research papers of International conference of Environmental and Climate Technologies (CONECT 2019) illustrates the wide range of topics covered in the issue. All overviewed articles are published in the Special Issue (Part I and Part II) of the Journal of Environmental and Climate Technologies. Scientific articles are divided into 5 thematic clusters: renewable energy resources, energy efficiency, policy and policy tools, waste management and bioeconomy that charts energy, bioeconomy, climate change and environment nexus.**

Keywords **– Bioeconomy; climate changes; energy efficiency; environmental aspects; low emission technologies; policy tools; renewable energy resources; waste management**

1. INTRODUCTION

Climate change has been a hot topic over the last few decades. It is widely recognised that energy and energy systems play a major role in mitigation of climate change. Energy systems are defined by [1] as combined processes of acquiring and using energy. 52 % of the world's population currently reside in cities; cities contribute around 70 % of energy related CO_2 emissions [2]. Therefore, many authors have concentrated on urban energy systems specifically. Within cities and in rural areas alike, energy is used for heating, cooling, lighting, mobility, communications - almost every part of everyday life depends on energy. Therefore, increasing energy efficiency and share of renewables in energy production are topical issues for society. Energy efficiency impacts the individual; for instance, in the form of energy costs, and individuals can have impact on overall energy consumption by developing energy saving habits, choosing to invest in buildings and household appliances that are energy efficient. In the end user sector, points for applying pressure are building energy efficiency, transportation, heating and cooling. The nearly zero-energy concept for the building sector has been discussed based on existing examples [3] and economic feasibility [4]. A specific subject regarding energy efficient buildings are energy efficiency for historical buildings. This comes with an entirely different set of challenges that, for the most part are related to protection of cultural and historical value of buildings [5]–[7]. Fundamental significance in transition to low-carbon society is given to so called "energy communities" [8]. These communities can be either "place based" or "non place based". As defined by

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Stefano et al. smart energy communities are areas the inhabitants of which aim to become energy efficient and powered by renewable and local energy sources. Forms of energy communities have been developing in Europe since the 1970s and 1980s and there are now a great number of communities that can be viewed as examples of "energy community" – to the extent that their number can be counted in the thousands. A life cycle based decision-making approach for renewable energy source (RES) selection for net-zero energy communities is used by [9]. Research on zero-energy hydrogen economy with hydrogen as the main energy carrier has shown that so far high complexity and investment costs of hydrogen energy costs makes this feasible as a solution for communities rather than single buildings. However more research is needed as well as measures for increasing acceptance of hydrogen technologies by the general public [10]. The European Federation of renewable energy cooperatives (established within the European Project *REScoop* 20-20-20) accounts so far for 1500 energy cooperatives [11]. Various companies producing products or services are also the end-user parts of energy systems. For them, it is important to implement energy efficiency measures and develop effective energy management systems [12], in order to reduce energy consumption per unit of product and production of waste. Implementation of such systems reduce the ecological footprint of a company, but also influence its financial performance. Depending on energy efficiency and management measures implemented, the influence can be positive or negative influence [13], concentrates on large companies and suggests that more research should be done on small and medium scale companies. Reduction of ecological footprint happens not only in energy consuming production processes; it is important also for office buildings. The system dynamics approach is applied for green office building performance assessment by [14]. Energy management systems are important tools for increasing energy efficiency on different scales and are impossible to implement without qualitative energy data collection and management. Liua [15] offers insight on effective energy data management on the national level. Another example of nationwide energy data collection and analyses is given by [16].

Increasing the share of renewables in energy production while sustaining energy security and doing so in an economically feasible way, is a nation-wide issue. Renewable energy brings about new challenges, such as, integration of various and characteristically different energy sources in a common energy system. Autonomous power supply systems can offer reliable on-site energy sources for small isolated public or private utility devices, for example, street lighting. Such systems generally consist of several modules: primary source of power, backup power supply, uninterruptible power supply, control system and energy storage [17]. The concept of autonomous power supply fuelled by renewable energy sources in rural areas in Kazakhstan has been discussed by [18]. It was concluded that the power storage device is the key component in order to make solar and wind power-based system autonomous. Well-developed and energy efficient or renewable energy based public transportation system can reduce environmental impact from transportation. Chang [19] discusses benefits from using renewable energy sources in urban transportation systems.

However, to promote renewables in nation-wide energy supply, EU countries are looking at energy production on a larger scale than autonomous street lights, separate passive or self-sustaining buildings and separate vehicles operated by renewable energy sources. The European Commission has been continuously developing policies for promoting use of renewable energy in its member states since the first Directive 2001/77/EC that set specific targets for consumption of energy produced by RES. Papież et al. [20] Increased share of RE is seen as a way to reduce EU energy systems vulnerability to energy imports and global energy crises [21]. First Directive after Latvia joined EU Directive 2009/28/EC set goals to

be reached by 2020 which included 20 % reduction in the EU greenhouse gas (GHG) emissions below the 1990 levels, raising the share of the EU energy consumption produced from RES to 20 %, and a 20 % improvement in EU's energy efficiency. More ambitious goals are set for year 2030 and 2050 [22]. Trends of energy development in the Baltic Sea Region have been assessed by [22] using multi-criteria analysis methods. Assessment covers the period from 2008 to 2015 and concludes that wind and solar energy have developed the most over the analysed period, since RES used in 1995 was, in general, either hydropower or biomass. EU countries were also encouraged to cooperate in order to achieve set energy targets by the legal framework for the use of cooperation mechanisms set in the Renewable Energy Directive. Countries that have reached beyond their set targets (Cyprus, France, Germany, Greece, Ireland, Latvia, Luxemburg, Malta, Portugal, Slovakia, Slovenia, Spain, The Netherlands, and the United Kingdom) could potentially become so called "off taker countries" and use cooperation mechanisms to trading their surplus to countries that potentially falls short of set goals (such as Bulgaria, Croatia, Czech Republic, Estonia, Finland, Italy, Lithuania and Sweden) [23]. Several barriers for host and "off taker" countries have been identified and discussed by [23], for example, public reaction in the host country difficulties in communicating benefits, different uncertainties about energy prices and state aid. EU ability to reach set targets for 2020 has been discussed by various other authors [24]–[26]. Walnum et al. [27] from Norway brings to attention gaps between planning and visions on national and regional level and real potential for improving energy performance on the community and individual level. The effects of new-to-the-market climate change mitigation technologies on reaching renewable energy and climate change mitigation tools has been assessed by Bel [28]. Achieving renewable energy targets is in large part dependant on innovative technologies. For example, about 25 % of electricity consumers are said to be already equipped with smart meters. Further development of various smart energy systems elements will allow to increasingly use decentralised energy sources. Intelligent inverters can increase distribution grid's capacity to the host renewable energy, for example, photovoltaics [29].

It has also been stated that energy systems themselves are also subject to the impact of climate change. Article by Cronin [30] gives review of research articles on climate change impacts on energy systems at end user as well as supply side – energy production from renewable and non-renewable energy sources. Climate change already affects all aspects of human life; therefore it should be our priority to plan how to adapt to these changes. Community scale energy systems adaptation model has been developed for community scale planning in Canada [31]. An important aspect that influences energy systems is the availability and quality of water. Water is used for both fossil (extraction, transportation, processing) and renewable resources (growing feedstock crops for biofuels, energy generation in hydroelectric power stations (HPP) or from wave energy). Impacts of water accessibility on energy systems have been assessed by Guerra [32].

2. OBJECTIVES AND SPECIAL ISSUE

As energy and environmental including climate change problems research papers presented in the journal cover a wide range of aspects which are presented in 5 thematic groups: renewable energy resources, energy efficiency, waste management, policy and policy tools and bioeconomy.

3. OVERVIEW OF THE PAPERS INCLUDED IN THIS SPECIAL ISSUE

Fifty-two papers of this Special issue can be classified in five themes, as shown in Table 1. The remainder of this section highlights how each author or team of authors contributed to the five themes.

TABLE 1. THEMES OF THIS SPECIAL ISSUE AND THE PAPERS CONTAINED IN EACH THEME

No.	Paper title	Authors
Theme 1. Renewable energy resources		
1.	Progress in renewable energy technologies: innovation potential in Latvia	Suharevska et al. (2019)
2.	Performance evaluation of an active PCM thermal energy storage system for space cooling in residential buildings	Rucevskis et al. (2019)
3.	Life cycle cost analysis of biogas production from *Cerathophyllum Demersum*, *Fucus Vesiculosus* and *Ulva Intestinalis* in Latvian conditions	Pastare et al. (2019)
4.	Multi-criteria analysis to select renewable energy solution for district heating system	Polikarpova et al. (2019)
5.	Solar energy in low temperature district heating	Pakere et al. (2019a)
6.	Analysis of energy supply solutions of dwelling buildings	Prodanuks et al. (2019)
7.	Integration of Sun PV electricity in centralized heating systems	Delle et al. (2019)
8.	New PV micro-modules on standard roof tiles	Wujek et al. (2019)
Theme 2. Waste management		
1.	Towards efficient waste management in Latvia: an empirical assessment of waste composition	Kubule et al. (2019a)
2.	Paper waste recycling. Circular economy aspects	Ozola et al. (2019)
3.	Single cell oil production from waste biomass: review of applicable industrial by-products	Spalvins et al. (2019)
4.	Ecological feasibility of applying technology in recycling garment and knitwear production	Kadnikova et al. (2019)
5.	Potential of energy willow plantations for biological reclamation of soils polluted by ^{137}Cs and heavy metals, and for control of nutrients leaking into water systems	Rodzkin et al. (2019)
6.	Numerical evaluation of probability of harmful impact caused by toxic spill emergencies	Skob et al. (2019)
Theme 3. Energy efficiency		
1.	Estimation of carbon emission reduction from upgrading the DH network to the 4th generation. Multivariate linear regression model	Pakere et al. (2019b)
2.	Latvian electric vehicle fast charging infrastructure: results of the first year of operation	Rubenis et al. (2019)
3.	Survey research of selected issues the Sick Building Syndrome (SBS) in an office building	Gladyszewska-Fiedoruk (2019)
4.	Energy efficiency obligations and subsidies to energy intensive industries in Latvia	Locmelis et al. (2019)
5.	Life cycle assessment of different low temperature district heating development scenarios: a case study of municipality in Latvia	Feofilovs et al. (2019)
6.	Solar facade module for nearly zero energy building. Optimisation strategies	Sirmelis et al. (2019)

7.	Empirical model of cost reduction in local DH systems. Low temperature approach	Blumberga et al. (2019a)
8.	Sustainability analysis of manufacturing industry	Kubule et al. (2019b)
9.	Is the high quality *Baukultur* a monkey wrench in the global climate challenges?	Blumberga et al. (2019b)
10.	Development features of heat power industry legislation in Russia	Penkovskii et al. (2019)
11.	CFD modelling of biomass mixing in anaerobic digesters of biogas plants	Conti et al. (2019)
12.	Optimization of the effective heat supply radius for the district heating systems	Postnikov et al. (2019)
13.	On the imaginary accuracy of the LCA on the basis of the houseboat in Hamburg (holistic approach)	Grajcar et al. (2019)
14.	Mechanical behaviour of polylactic acid foam as insulation under increasing temperature	Doyle et al. (2019)
15.	Thermodynamic, environmental and economic simulation of an organic Rankine cycle (ORC) for waste heat recovery: Terceira Island case study	Rocha-Meneses et al. (2019)
16.	Economic performance of net-zero energy community under reward-penalty mechanism considering PV system reliability	Lu et al. (2019a)
17.	Sustainable electronic product development in the Baltic Sea region: a regional gap analysis of lab testing services	Philipp et al. (2019)
18.	Implementing user behaviour on dynamic building simulations for energy consumption	Jimenez-Bescos et al. (2019)
19.	Sprayed water flowrate, temperature and drop size effects on small capacity flue gas condenser's performance	Priedniece et al. (2019)
Theme 4. Policy and Policy Tools		
1.	Assessment of the implementation of sustainable energy action plans at local level. Case study of Latvia	Jekabsone et al. (2019)
2.	Methods to evaluate electricity policy from climate perspective	Rozentale et al. (2019)
3.	Tourist transportation generated carbon dioxide (CO_2) emissions in Latvia	Grizane et al. (2019)
4.	Life cycle assessment of foam concrete production in Latvia	Zimele et al. (2019)
5.	Implementation of blockchain technology in insurance contracts against natural hazards: a methodological multi-disciplinary approach	Pagano et al. (2019)
6.	Impact of zones with special status on the environment (experience of Russia and Kazakhstan)	Turgel et al. (2019a)
7.	Implementation of the smart city technology for environmental protection management of cities: the experience of Russia and Kazakhstan	Turgel et al. (2019b)
8.	Evaluation of the environmental engineering study programme at University	Pubule et al. (2019)
9.	Use of multi-criteria TOPSIS analysis to define a decarbonization path in Colombia	Diaz et al. (2019)
10.	Key factors for successful implementation of energy efficiency policy instruments: a theoretical study and the case of Latvia	Aboltins et al. (2019)
11.	Power sector flexibility through power to heat and power to gas application – system dynamics approach	Gravelsins et al. (2019)
12.	Cost allocation model for net-zero energy buildings under community-based reward penalty mechanism	Lu et al. (2019b)

Theme 5. Bioeconomy		
1.	Circular economy and bioeconomy interaction development as future for rural regions. Case study of Aizkraukle region in Latvia	Muizniece et al. (2019)
2.	New vision on invasive alien plant management system	Zihare et al. (2019)
3.	Why biopolymer packaging materials are better	Silva et al. (2019)
4.	Parameters that affect electricity consumption in fish freezing. Case study	Terehovics et al. (2019)
5.	The evaluation of factors affecting bioeconomy development using transdisciplinary approach	Indzere et al. (2019)
6.	The role of environmental evaluation within circular economy: an application of life cycle assessment (LCA) method in the detergents sector	Paolotti et al. (2019)
7.	When bioeconomy development becomes a biomass energy competitor	Lauka et al. (2019)

3.1. Renewable Energy Resources

The potential of renewable energy technologies is evaluated in **Progress in renewable energy technologies: innovation potential in Latvia** by Suharevska et al. (2019). The development of renewable energy technologies (RET) depends on a wide range of criteria and regulations. To evaluate which RET (solar photovoltaic (PV), wind power plants (WPP), HPP or bio-energy plants) has the greatest potential in Latvia, the most suitable is a multiple criteria decision making (MCDM) approach. The proposed MCDM methodology involves the Technique for Order Preference by Similarity to the Ideal Solution (TOPSIS) model based on information entropy, which contributes as criteria weighting tool. The study investigates seven main criteria from technical, economic, environmental and social aspects. The research results show that, according to the best available examples of RET, HPP still plays a substantial role in Latvia, the most promising RET developments are based on bio-energy and wind renewable energies.

Performance evaluation of an active PCM thermal energy storage system for space cooling in residential buildings by Rucevskis et al. (2019) presents a numerical simulation-based study that evaluates the potential of an active phase change material (PCM) incorporated thermal energy storage (TES) system for space cooling in residential buildings. In the proposed concept, TES system is composed of stand-alone PCM storage units which are installed between the concrete ceiling slab and the ceiling finishing layer. Effectiveness of the system under the typical summer conditions of the Baltic States is analysed by using computational fluid dynamics (CFD) software *Ansys Fluent*. The outcome of this investigation would be helpful in selecting the key characteristics of the system in order to achieve the optimum performance of an active TES system for space cooling of buildings in similar climates.

Life cycle costs of a co-digestion plant of cattle farm manure and locally available freshwater macrophyte and marine algae are analysed in **Life cycle cost analysis of biogas production from *Cerathophyllum Demersum, Fucus Vesiculosus* and *Ulva Intestinalis* in Latvian conditions** by Pastare et al. (2019). The weak points of scenarios are large capital investments, electricity sale price (and the application of feed-in tariff). As naturally grown algae and macrophytes are used, they are also sensitive to weather conditions each year as available amounts of biomass might change and decrease. Net Present Value is positive only for *C. demersum* with Internal Rate of Return of –14 % and Discounted Payback Period of 11 years.

The study **Multi-criteria analysis to select renewable energy solution for district heating system** by Polikarpova et al. (2019) is focused on how to choose the most suitable

renewable energy solution using multi-criteria analysis to district heating system. Making choices is based on the following factors – economic, environmental and social. In this case, the study focused on five indicators: resources costs, total investments, reduction of greenhouse gas emissions, specific weight of renewable energy resources and impact on utilized land. Three situations have been compared – the current situation: gas boiler, the planned situation: solar collectors 21 595 m^2 + accumulation tank 8000 m^3, and alternatives: solar PV panels 5504 m^2 – heat pump COP 3 are used in the estimation. The multi-criteria decision-making analysis has shown that solar collectors 21 595 m^2 + accumulation tank 8000 m^3 are considered the best alternative. The methodology is based on choosing a solution for a district heating company in Latvia.

Solar technologies are flexible and can be used for both centralized and decentralized energy production. The main aim of the article **Solar energy in low temperature district heating** by Pakere et al. (2019a) is to compare different solar technologies and configurations for integration into the DH system. The multi-criteria analyses allow to compare different solar system alternatives that cannot be compared directly due to differences in the scale, type of energy produced and consumed, the investment levels etc. For the particular DH system the most desirable solution is the PVT panel integration with the area of 1000 m^2 which is aligned with the actual DH companies power consumption. However, the results are strongly impacted by the assumed investment levels, efficiency of the technologies and other assumptions that could be further analysed with the help of sensitivity analyses.

Individual heating consumption for dwelling buildings has an important part in Latvia's energy balance. Increasing energy efficiency and reducing primary energy in the household sector can play a role in national energy targets. **Analysis of energy supply solutions of dwelling buildings** by Prodanuks et al. (2019) analyses three different heating systems having focus on pellet boiler and solar collector combined system. Performance of existing solar collectors are analysed and solar collector system performance ratio is determined. Costs including investments, fuel and maintenance have been analysed and a comparison between systems is made using the indicator – costs per produced unit of energy. Results show that the performance of solar collector system should be increased or investments should decrease to meet cost effectiveness of other analysed heating systems.

During the experimental research an algorithm was developed in the research **Integration of sun PV electricity in centralized heating systems** by Delle et al. (2019) for a guide on the introduction of solar panels (PV) in centralized heat supply (CHS) companies and the Strength, Weakness, Opportunities and Threats (SWOT) analyses and the developed algorithm action blocks were performed. The SWOT analysis was carried out for a practically implemented project, which, as a result of the implementation of the centralized heat supply system, uses solar power with a total capacity of 30 kW. We found that in Latvia, the areas that are suitable for solar panels are several times higher than those required by the systems. The main tasks of the work: to analyse and study available literature and information on solar PV integration into CHS; analyse available solar PV power generation equipment and technologies; develop a roadmap for easy and understandable deployment of solar panels in the company.

Various technologies available on the solar photovoltaic cell market have been reviewed in **New PV micro-modules on standard roof tiles** by Wujek et al. (2019). The method of photovoltaic micro-modules implementation on standard roof tiles was shown. The possible roof tiles were chosen. Problems related to micro PV modules design and concept of final product developed at *Electrotile* Company have been described. It was shown that the solar

panel modules consisting 6 two-cell setups on the *Tysenia* roofing tile generated power of 38.5 W or 42 W depending on cell type.

3.2. Waste Management

Waste management system is a complex system that involves numerous waste streams, collection schemes, treatment processes and various actors. But as well as many other systems, waste management has recently experienced new and more sustainable development trends, including the promotion of circular economy and increased material recycling. Hence there is the need for the implementation of an improved waste management system that requires a significant and thorough planning stage, the results of which will significantly depend on the availability of detailed information of the possible waste flows and waste composition. The aim of the paper **Towards efficient waste management in Latvia: an empirical assessment of waste composition** by Kubule et al. (2019a) is to experimentally determine and analyse the composition of unsorted municipal waste to provide the assessment for incorporating waste composition analysis into further planning and modelling of a next generation waste management system in Latvia. The experimental results indicate that the unsorted municipal waste stream comprises up to 32.9 % of recyclable materials and 29.2 % of biodegradable wastes. Thus, the almost 60 % of the waste currently being subjected to unsorted waste management system in Latvia could potentially be source separated, ensuring higher quality of the recovered materials and promoting circular value chains. The results indicate a slight difference between waste composition in different waste management regions, thus noting that, in addition to the number of inhabitants and their habits, the local system in each waste management region may influence the composition of the collected wastes.

Ozola et al. (2019) explained in the study **Paper waste recycling. Circular economy aspects**, that paper waste is a raw material for lots of products with different added value. The engineering, economic and environmental aspects of paper waste recycling are analysed for production of composite material, cellulose nanofibers and nanocrystals, bricks with paper components, porous carbon, film of biopolymer, enzymatic sugar and bioenergy: bioethanol, hydrogen and biofuel. The multi-criteria analysis allowed to find out the most feasible paper waste recycling product in case of four product groups: egg packaging boxes, cardboard, reused paper, cellulose nanomaterials (nanofibers and nanocrystals). The production of cellulose nanofibres and cellulose nanocrystals has an advantage over egg packaging and cardboard production as well as reusable paper.

In the article **Single cell oil production from waste biomass: review of applicable industrial by-products** by Spalvins et al. (2019) analysed, that single cell oil (SCO) is an attractive alternative source of oil, which, depending on the fatty acid composition, can be used as a feedstock for biodiesel production, as an ingredient for pharmaceuticals or as a source of essential fatty acids for human and animal consumption. However, the use of SCO is limited due to use of relatively expensive food or feed products in the cultivation of SCO producing microorganisms. In order to reduce SCO production costs, the use of cheaper feedstock such as biodegradable agro-industrial wastes are necessary. At the same time, the microbial treatment of biodegradable wastes ensures the neutralization of environmentally harmful compounds and reduces negative impact on the environment. Oleaginous microorganisms are capable of fermenting a variety of industrial by-products, waste products and wastewaters, however further discussion on properties of the waste materials is necessary to facilitate selection of the most appropriate waste materials for SCO production. Thus, this review compares various industrial waste products that can be used as cheap feedstock for

the cultivation of SCO producing microorganisms. Industrial waste products, by-products and wastewaters are compared according to their global availability, current use in competing industries, required pre-fermentation treatments, oleaginous microorganism cell concentrations and SCO yields.

In the work **Ecological feasibility of applying technology in recycling garment and knitwear production** by Kadnikova et al. (2019) the issue of reducing the environment pollution by means of recycling of waste of the garment and knitwear industry is reviewed. Comparative assessment of the ways of obtaining knitted fabric from the recycled yarn with the help of different technological methods and processing on the auxiliary equipment for waste recycling is conducted. Quality and environmental and economic assessment of the developed technology for obtaining fabric from the recycled yarn is provided.

Potential of energy willow plantations for biological reclamation of soils polluted by ^{137}Cs and heavy metals, and for control of nutrients leaking into water systems by Rodzkin et al. (2019). Willow is a low-maintenance crop that has potential for energy production and enhancing the local environment. The area of commercial plantations of willow in Europe is mostly concentrated in Sweden, with more than 20 000 ha. Willow trees are used not only for energy production, but also for reclamation of polluted soils because a plantation may grow for 20–25 years, with a three-year period of harvesting. Our research covers issues of reclamation of soils contaminated by radionuclides and heavy metals, and decreasing of eutrophication of water ecosystems with using willow plantations. The field studies of phytoremediation of soil contaminated by ^{137}Cs by willow plants were conducted in eastern Belarus, in the area where agricultural activity was banned after Chernobyl disaster. This region is heavily polluted with ^{137}Cs (from 185 to 555 kBq/m^2) and heavy metals. The transferring factors of accumulated ^{137}Cs and heavy metals from the soil to willow biomass were determined. The field experiments showed that willow does not accumulate actively Cd and Pb, but it accumulates Zn, Cu and Mn intensively. The potassium application decreases the accumulation of 137Cs in willow biomass and increases accumulation of Cu, Zn and Mn, but has no influence on accumulation of Cd and Pb. Our results confirmed that soils polluted with radionuclide and heavy metals could be used for willow cultivation as energy crop, if adequate management is applied. The different potential of the willow species concerning heavy metals accumulation was also established. The yield of willow biomass on polluted soils achieved 11.5–12.8 DMg ha^{-1} per year, depending on variety, that is competitive with the ordinary yield of willow on mineral fertile soils. Willow plantations also may be used for accumulations of nutrients like nitrogen and phosphorus in watersheds. It enables to decrease impact for water ecosystems and to control eutrophication.

Numerical evaluation of probability of harmful impact caused by toxic spill emergencies by Skob et al. (2019). The purpose of the work is to assess the degree of inhalation damage of a person exposed to the toxic cloud of liquefied gas evaporation from a spill spot of various shapes. The mathematical model of liquefied gas spill evaporation which arose as a result of accidental destruction of the storage capacity and further dispersion of the gas impurity in the atmosphere surface layer was developed. The computational technology for determining the fields of conditional probability of human inhalation damage by a toxic gas based on a probit analysis is developed. The mathematical model takes into account the flow compressibility, complex terrain, three-dimensional nature of the dispersion process, and the presence of toxic liquid substance evaporation from the arbitrary spill spot with varying intensity. The model allows obtaining space-time distributions of the toxic gas relative mass concentration and inhaled toxidosis which is necessary to determine the fields of the human damage probability based on the probit analysis. For different ellipticity of the

hydrogen cyanide spill elliptical spot the fields of probability of human mortal damage are obtained and the influence of spot ellipticity on the scale of the consequences of an accident of this type is analysed. The developed technology allows carrying out automated analysis and forecasting in the time and space of the damage probability of a person exposed to the toxic gas as an indicator of the safety of the technogenic object.

3.3. Energy Efficiency

In the study **Estimation of carbon emission reduction from upgrading the DH network to the 4th generation. Multivariate linear regression model** by Pakere et al. (2019b) authors explained, that the district heating (DH) system consists of three basic elements – a heat source, heating network and heat consumers. All of these elements have a definite role in the overall development of the DH system, and the transition to 4th generation DH (4GDH) involves changes in each of those elements that interact with each other. Therefore, various related processes form the potential energy savings and reduction of CO_2 emissions when introducing 4GDH as a whole system in all elements. To estimate the potential outcome from such projects, complex engineering calculations are required, which are not always possible without relevant expertise.

The article **Latvian electric vehicle (EV) fast charging infrastructure: results of the first year of operation** by Rubenis et al. (2019) presents a preliminary analysis of Latvia's national EV fast – charging network after its first year of operation. The first phase of Latvia's national EV fast-charging network was launched in 2018 with 70 charging stations on the TEN-T roads and in the largest towns and cities. The article looks at the initial results, both looking at the total capacity utilization for individual charging stations, determining the hourly charging distribution; and to the utilization of the network as a whole. The results present that there is a very large dispersion of data, most of the charging events happening in a few charging stations in and around the capital of Latvia. However, there have been charging events in all charging stations, even the most remote ones. Even more skewed distribution was observed analysing the charging habits of the EV users, with 10 % of users accounting for more than half of the charging events. This should be taken into account when considering applying the results in the future, expecting larger number of electric vehicles in Latvia.

The reason why the Sick Building Syndrome appears is as a result of the poor flow of fresh air into rooms. It could cause various ailments, although it is difficult to determine their source and the symptoms disappear soon after leaving the building. The paper **Survey research of selected issues the Sick Building Syndrome (SBS) in an office building** by Gladyszewska-Fiedoruk (2019) discusses the sources of indoor air pollution, symptoms of Sick Building Syndrome and shows solutions how to avoid the phenomena of "sick" buildings. In addition, the results of questionnaire surveys on the well-being of employees, which were carried out in an office building in Warsaw, were presented. The vast majority of respondents spend 8 hours in the building daily, during which their well-being deteriorates. More than half of the respondents felt typical symptoms of Sick Building Syndrome. To avoid the formation of "sick building" air should be circulated regularly. The air exchange method is not important.

The European Union's climate and energy policy for 2030 sets ambitious targets and will challenge current energy use patterns. At the same time, policy objectives are determined to maintain affordable energy for business and consumers, which means that energy and climate goals should be achieved in the most cost-effective way. There is a well-known energy efficiency gap between effectively implemented energy efficiency measures and potentially economically viable ones. Authors in the study **Energy efficiency obligations and subsidies**

to energy intensive industries in Latvia by Locmelis et al. (2019) have made a statistical analysis on energy costs intensity of manufacturing industries in Latvia compared to other Baltic Sea countries and have consented that three most energy consuming manufacturing industries in Latvia show a higher share of energy costs in total production costs than their peers over a long period of time, indicating the clearly visible possibilities for energy efficiency improvements. The paper analyses the amounts of reimbursements and their breakdown by manufacturing industries, identifying the most important beneficiaries of subsidies. The authors argue that beneficiaries should direct these subsidies to further energy efficiency improvements.

Sustainable heating solutions involving renewable energy sources and low supply/return temperatures for district heating are evolving. Low temperature use in district heating allows reducing the heating operation costs significantly and at the same time holding the sustainability criteria. However, an in-depth study on environmental impacts during the life cycle of low temperature district heating had not been conducted until now. Thus, the study **Life cycle assessment of different low temperature district heating development scenarios: a case study of municipality in Latvia** by Feofilovs et al. (2019) aims to find the best development scenarios for development of local low temperature district heating. For this purpose, the methodology adopts the life cycle analysis approach that allows assessing the environmental impacts according to a variety of environmental performance criteria. The results of the study have shown an improvement in the overall environmental performance towards the transition of a conventional 3rd generation district heating to low temperature concept including the effects of reconstruction and modernization of the boiler house. A set of potential development is proposed. Specifically, the scenario implementing low temperature district heating with solar PV has shown the best score for the environmental performance. The scenario with implementation of low temperature district heating without solar PV did not show a significant improvement in environmental performance under operation conditions of a pilot case study.

The study presented in paper **Solar facade module for nearly zero energy building. Optimisation strategies** by Sirmelis et al. (2019) is the continuation of small-scale passive solar wall module testing to evaluate: 1) the impact of phase change material embedded in the building envelope on indoor air temperature in comparison to reference wall insulated with mineral wool; 2) the impact of Fresnel lens on heat transfer processes in designed module compared to Poly(methyl methacrylate) (PMMA) acrylic glass. Six different solar wall modules and a reference wall module were built and tested in a laboratory under controlled conditions. Compared to previous studies, changes in the experimental setup were made – solar radiation intensified, simulated outdoor temperature adjusted. The study shows explicitly the phase change melting processes in different modules tested, describing the differences between modules and impact of Fresnel lens and insulation solutions. Room temperature with solar wall modules after the full cycle of charging and discharging latent and sensible energy (24 h) is higher than in the reference wall. Two of 3 of proposed solar wall modules with Fresnel lens are more effective than modules with PMMA.

The present work **Empirical model of cost reduction in local DH systems. Low temperature approach** by Blumberga et al. (2019a) indicates, that improving the efficiency of heating systems can give a tremendous contribution towards EU energy efficiency target for 2030. Significant heat losses are one of the main disadvantages of the dominating high temperature district heating (DH). Even in summer the high retention time of water in the network leads to thermal losses from domestic hot water reaching up to about 30 %. Empirical model based on experimental data of heat energy consumption in multifamily buildings is

created for economical optimisation of operation of DH systems. The methodology has been developed that allows estimating the total energy cost savings (including losses) of buildings associated with the reduction of heat loss in the system, by reducing the supply flow temperature, and increasing electricity consumption by increasing the mass flow rate of water in the network.

This study **Sustainability analysis of manufacturing industry** by Kubule et al. (2019b) provides an analysis to identify the comparative sustainability of the subsectors of manufacturing industry in Latvia. We assess the availability of national statistics data for development of absolute and specific indicators, which are further used for sustainability evaluation by multi-criteria analysis, particularly the TOPSIS method. Overall nine separate indicators were used for the description of three sustainability pillars. The results provide the distribution of manufacturing sub-sectors accordingly to their comparative sustainability, and thus the rubber and non-mineral metal manufacturing sectors and wood and wood products manufacturing are evaluated as having the lowest comparative sustainability and most appropriate for further investigation regarding the development of sector specific energy efficiency benchmark.

EU's 2030 climate package calls for raising energy efficiency, usage of RES and decreasing the carbon footprint. There are stringent requirements for new buildings, but the energy efficiency potential in existing building stock is still not fully explored. The latest trend in urban energy efficiency are Positive Energy Block (PEB) strategies for new developments. It includes raising building energy efficiency, optimizing energy flow and implementing renewable energy sources. Transforming all the existing blocks in city centre to a PEB`s would radically change the pattern of energy supply and consumption. European cities have historic centers with great architectural and cultural value. Any urban regeneration strategy must respect and preserve historic values. The paper **Is the high quality *Baukultur* a monkey wrench in the global climate challenges?** by Blumberga et al. (2019b) describes double multi-criteria analysis evaluating urban blocks from the perspective of energy efficiency and cultural heritage with the goal to select the sample block for "Smart urban regeneration – transition to the Positive Energy Block" case – study. Proposed criteria for multi-criteria analysis to evaluate cultural heritage, liveability and energy efficiency potential describes well specific qualities of urban block. The obtained results show that blocks with higher cultural value show less energy efficiency potential and vice versa. It is recommended to apply cultural value and liveability qualities in smart urban regeneration process to the blocks with high energy efficiency potential.

In Russia, the legislative support for the construction and operation of heating systems is permanently developing and improving. The federal law "On heat supply" adopted in 2010 is the basic and most important document that regulates the work of heating systems. The paper presents the main documents that regulate the heat supply industry in the Russian Federation, and a brief description of the main stages of heating system life cycle and problems solved in each of them. This paper **Development features of heat power industry legislation in Russia** by Penkovskii et al. (2019) proposes solutions aimed at enhancing the effectiveness of decisions made in the field of heat supply. It formulates the proposals on organization and regulation of the activities of all the participants in heat supply in the stage of long-term planning of heating system expansion, because well-founded and rational planning of construction and expansion of the systems is a basis for their efficient operation.

CFD modelling of biomass mixing in anaerobic digesters of biogas plants by Conti et al. (2019). A cut in greenhouse gas emissions, increment of energy from renewables and improvement in energy efficiency represent the three key targets for future energy systems.

Among the available bioenergy technologies, biogas production via biodegradation and anaerobic digestion is a widely applied approach, not only to produce biofuels but also to manage industrial and domestic organic waste. Within biogas production, a sufficient mixing of the organic mass is a crucial step to ensure high biogas yields by bacteria and enzymes. Measurements of the electric power consumption of biogas plants revealed that the electrical energy demand of the stirrer system has a high share of the total electricity consumption of a biogas plant. Investigations on real biogas digesters to optimize the mixing process are cost and time intensive. Therefore, laboratory prototypes and computational simulations represent promising alternatives to analyse and improve the efficiency of mixing systems. In this paper, a computational fluid dynamics (CFD) model is presented, which is applied to commercial stirring systems. The case of two propeller stirrers, located in diametrically opposite positions in a tank filled with ca. 1400 m^3 of substrate is described in detail. For the simulation, the rheology of the fluid is adapted to a biomass with 12 wt % dry matter content and obeying the non-Newtonian generalized Ostwald-de Waele power law. The developed simulation procedure considers the rotation angle of each propeller and its height. A total of 441 mixing configurations are calculated and evaluated in terms of the technical benefit. The investigation reveals that locations of the rotors far away from the bottom and high rotational angles cause advantageous fluid dynamics.

Optimization of the effective heat supply radius for the district heating systems by Postnikov et al. (2019) considers the problem of determining the effective (optimal) heat supply radius. Heat supply radius is the transportation distance of heat energy in the district heating systems (DHS), within which the highest indices of economic efficiency of district heating to consumers are respected. To solve this difficult and multifactorial problem, a bi-level approach has been proposed. This approach allows finding the optimal framework of territorial areas of district heating while fulfilling the necessary requirements for thermal hydraulic modes in heat networks and for reliability of heating to consumers. The methodology for solving the formulated problem is based on bi-level programming methods, models of theory of hydraulic circuits, nonlinear optimization methods, nodal reliability indices (availability factor, failure-free operation probability), Markov random processes models and other methods and models. A case study has been conducted using the developed methodological apparatus for the actual DHS scheme of the Irkutsk city (Russia, Siberia).

Within the paper **On the imaginary accuracy of the LCA on the basis of the houseboat in Hamburg (holistic approach)** by Grajcar et al. (2019), to our knowledge, for the first time in the history of the life cycle assessment, the LCA analysis of the houseboats used for residential purposes has been conducted while testing a new software program eLCA in its Beta version. In cooperation with the Coop Waterhouse GmbH and with the Architektenbüro PlanWerk, the houseboat Swan, due to its extraordinary solutions for energy supply, has been chosen for the first attempt at analysing uncertainty in its LCA with a focus on the energy supply components as well as on energy input. Results discuss energy usage, being responsible for half of the total CO_2 e-missions, and its uncertainty with regards to the next 50 years of the houseboat's lifetime.

The research within **Mechanical behaviour of polylactic acid foam as insulation under increasing temperature** by Doyle et al. (2019) considers the measures to increase the share of renewables in heat generation, combined with increased energy efficiency that provide direct emissions reduction on the heating sector. Energy efficiency measures, as well as the role-out of sustainable heating technologies such as district heating networks have one key actor: insulation. However, state of the art insulating materials such as polyurethane or

polystyrene have severe environmental drawbacks incompatible with today's transition to a circular economy, and are the Achilles' heel of the sector in terms of sustainability. Bio-based and biodegradable polylactic acid (PLA) foam could be a promising replacement for fossil-based polymeric insulating foams. This study provides data on the mechanical behaviour of expanded PLA foam under different temperatures, which will help to assess its potential use as insulation where the foam is subject to heat.

The aim of the study **Thermodynamic, environmental and economic simulation of an organic Rankine cycle (ORC) for waste heat recovery: Terceira Island case study** by Rocha-Meneses et al. (2019) is to analyse from the thermodynamic, environmental and economic point of view an ORC for heat recovery from urban waste, using R245fa as a working fluid on the example of Terceira Island (Azores). The proposed ORC system includes two evaporators, two turbines, a condenser, a pump and a generator. The thermodynamic model is created using the Visual Basic programming language. In order to analyse the influence of pressure, temperature and mass flow on net output, efficiency, and mass flow rate of the power plant, the sensibility analysis is carried out. The results show that from the energetic point of view, urban waste recovery (using an ORC) could be a viable solution on Terceira Island, since the maximum net output produced from this system for a mass rate of 19 727 tons is 485 kW. The efficiency of the ORC is 25 %. Environmentally, the incineration of the urban waste produced on the island is a positive solution for these residues since it will reduce the amount of waste deposited in the landfill. However, this project is not economically viable. The losses estimated in this study exceed 500 000 EUR (per year).

Economic performance of net-zero energy community under reward-penalty mechanism considering PV system reliability by Lu et al. (2019a). Economic performance of net-zero energy building/community (ZEB/ZEC) is an important factor that affects potential investors' decision on installing renewable energy systems (RES). A reward-penalty mechanism (RPM) is proposed for accelerating the development of zero energy communities, which is developed without considering the reliability effect from RES generation. However, an investigation is deserved for the reliability effect of RES on building economic performance. A case study is therefore conducted based on an assumed community consisting of 20 family houses, in which the electricity load was collected by the smart meter for more than one year. The results show that the proposed RPM works efficiently under an ideal condition, while the costs of the community and its buildings are greatly increased when the effect of PV system reliability is considered. Specifically, the total cost of the community under 1.0ZEC design is 5005 USD/yr in the first year, which increases to 11 341 USD/yr in the 25th year. By contrast, the total cost of the community under 1.2ZEC design is 5 243 USD/yr in the first year and increases to 9 607 USD/yr in the 25th year. It is believed that the results of this study can provide a progressive perspective for scheme makers and building owners in terms of its economic benefit. Development of enhanced RPM by considering system reliability will be investigated in our future work.

Sustainable electronic product development in the Baltic Sea region: a regional gap analysis of lab testing services by Philipp et al. (2019). The Baltic Sea Region (BSR) represents one of the most innovative areas within Europe with dominating SME sector. In order to keep the region and their product developments competitive, it is necessary to safeguard access to high-tech labs including test services. This can be realized only through regional networks of universities – business cooperation. The European Union started the project "Test-4-SME" in 2017 to investigate and promote laboratory networks for testing and assessment of electronic products developed by SMEs from BSR. In a BSR wide online survey, the project consortium identified existing gaps in the regional supply of open

laboratories together with shortcomings in services, expertise or test equipment, which is needed by SMEs for electronic product or devices testing. The authors who participate in the "Test-4-SME" project, conducted the survey and analysed the regional demand together with the availability of labs for SME sector in the BSR. The study focusses on the research question in which BSR regions there exist already university-business networks of open labs for SME and to which extent the offered services meet the regional demand. Therefore, an approach of a gap analysis is used, which is based on primary data gathered in a BSR wide survey together with expert interviews. The results of the study are discussed in the context of the existing literature and recommendations for future improvements are highlighted.

User behaviour influences the energy consumption of domestic properties with different range of variations and this has the effect on the results of building simulations based on default or general values, as opposed to implementing user behaviour. The aim of the paper **Implementing user behaviour on dynamic building simulations for energy consumption** by Jimenez-Bescos et al. (2019) is to evaluate and quantify the effect of implementing user behaviour in building dynamic simulation to calculate heating and domestic hot water energy consumption to reduce the performance gap. The results for space heating and domestic hot water from dynamic building simulations will be compared to actual energy bills for a general building simulation technique and a calibrated building simulation, incorporating user behaviour details. By using user behaviour details to create calibrated building simulations, a correlation to actual energy bills of over 90 % can be achieved for a dataset of 22 properties. This study has shown that by incorporating user behaviour into building simulations, a more accurate estimation of energy consumption can be achieved. More importantly, the methodology approach allows the user behaviour parameters to be collected by means of a questionnaire, providing an easy and low budget approach to incorporate user behaviour into dynamic building simulations to reduce the performance.

One of the main pollution types is air pollution, which has a significant impact on the surrounding environment and on living beings. Major source of air pollution is combustion processes. There are many flue gas treatment technologies around the world. In the paper **Sprayed water flowrate, temperature and drop size effects on small capacity flue gas condenser's performance** by Priedniece et al. (2019) a new, innovative flue gas treatment technology – fog unit – is introduced. The goal of the fog unit is to treat flue gases that are emitted from households. In the European Union, including Latvia, in the beginning of 2020 a directive will come into effect that will set limits for emissions and the effectiveness for incinerators in households. The main focus of this study was to determine the optimal operating mode for the fog unit by changing different operating parameters: sprayed water temperature, sprayed water flowrate and types of nozzles (drop diameters). The results have shown that the most optimal operating mode in terms of flue gas treatment efficiency and recovered energy is at water temperature: 20 °C, sprayed water flowrate: 250 l/h and nozzle: MPL1.12 M. However, the electrical consumption of water circulation pump leaves negative effect on this operating mode.

3.4. Policy and Policy Tools

The need for sustainable energy management at the municipal level is growing, in order to meet EU climate goals. Multiple initiatives have been launched to support municipalities in energy planning and strategy development process. Despite available support, research shows mixed results about implementation of plans and strategies. This research paper analyses what targets municipalities set, how they monitor implementation of their sustainable energy action plans (SEAPs) and searches for the most important factors that have enabled or hindered the

implementation of local SEAPs in Latvia. The article **Assessment of the implementation of sustainable energy action plans at local level. Case study of Latvia** by Jekabsone et al. (2019) shows that, in some cases, there is evidence that SEAP development is a project-based activity, supported by external experts. From the municipal personnel point of view, it is a project that ends with approved SEAP, but not a part of their future daily routine. Eventually implementation of the plan is difficult, because municipalities lack experience in daily management of energy data, distribution of responsibilities and implementation of procedures. Municipalities also tend to exclude important stakeholders in their SEAPs, like, the private, household and transport sectors, which lead to lower targets and lower achievements in (GHG) reduction.

Nowadays the government policies to mitigate climate change are many and they are being evaluated before and after implementation. There are many researches on how a climate change policy will affect the climate. However, there is very little amount of research done on policies that are not intended to mitigate or reduce climate change and which from the policy makers' point of view do not even have relation to climate change. The goal of this study **Methods to evaluate electricity policy from climate perspective** by Rozentale et al. (2019) is to review the electricity policy in Latvia and the aspects that can be evaluated under this policy, and by using multiple-criteria analysis to determine on what areas the electricity policy leaves the most positive effect – climate or consumers and other electricity market players. The outcome of the analysis shows that at the national level the National Energy and Climate Plan has the most positive effect on climate, proving that climate is taken into consideration mostly only under complex schemes.

Tourism has a close relation to travel and tourism transport. Transport is a source of CO_2 emissions. The aim of the research **Tourist transportation generated carbon dioxide (CO_2) emissions in Latvia** by Grizane et al. (2019) was to inspect tourist transportation (TT) CO_2 emissions caused by the tourist overnight trips, because any similar analysis up until now has not been made in Latvia. For the determination of the CO_2 emissions from the TT, a hybrid (top-down and bottom up) approach, correlation, regression was used. The authors' proposed algorithm for determining CO_2 emissions from the TT is useful in circumstances when the statistical data is not sufficient. In the research of regions of Latvia (NUTS 3) from 2012 to 2017, it was determined that the TT overnight trips indicated a reduction of CO_2 emissions of 475 t/year. IT is a positive approach in order to reach reduction of CO_2 emissions according to the EU criteria for 2030; however, it left a negative impact on the national GDP. Finding a solution to this economical problem is the aim of the next researches.

With global warming being increasingly discussed, solutions for reducing greenhouse gas emissions become more important in all industry sectors. The total energy consumed in the construction sector contributes up to 1/3 of all greenhouse gases emissions. A large part of it comes from cement production – 5 % of the total global emissions. Foam concrete is a lightweight concrete with good thermal properties and ability to reduce CO_2 emissions by reducing the use of cement due to its low density. The aim of **Life Cycle Assessment of foam concrete production in Latvia** by Zimele et al. (2019) this study is to determine impact on the environment with the use of Life Cycle Assessment (LCA) with focus on Global Warming Potential (GWP) for two different compressive strength foam concrete mixtures produced in Latvia by unique intensive mixing technology – turbulence with cavitation effect. Afterwards, the selected foam concrete mixtures are compared with alternative materials with similar compressive strength – aerated concrete and hollow ceramic blocks. The foam concrete mixture having 12.5 MPa compressive strength showed higher CO_2 emissions than hallow ceramic block. The majority of CO_2 emissions comes from Portland cement, which is a key

element in its composition. On the other hand, the foam concrete mixture having 2.4 MPa compressive strength showed higher CO_2 emissions than aerated concrete block. The majority of CO_2 emissions are due to foam glass granules, which is the main element contributing to the increased insulation properties of the material. A comparison of each foam concrete with analogue building material by compressive strength shows that the chosen foam concrete mixtures produce greater GWP than alternative materials. This research allows to identify the environmental impacts of different foam concrete mixture components and to improve these mixtures to achieve similar properties with less impact, for example, by replacing foam glass granules with granules made from recycled glass or replacing cement with flay ash, silica fume or recycled glass powder.

Risk insurance for disasters plays a relevant part in the implementation of risk reduction strategies during the pre-disaster phase. It is essential to support risk management towards decreasing the marginal risk allowing policy holders to transfer risk to avoid considerable financial loads from the costs incurred during the recovery phase in a post-disaster phase. There is evidence that the introduction of an integrated risk insurance strategy for community resilience planning is still lacking. Thus, this undermines the possibility to have proper optimized holistic risk management; on the one hand this strengthens pre-disaster risk mitigation measures, mostly relying on mitigative infrastructural solutions, and on the other hand it defines risk prevention strategies mostly connected to land planning and urban development better. The paper **Implementation of blockchain technology in insurance contracts against natural hazards: a methodological multi-disciplinary approach** by Pagano et al. (2019) will show how insurance markets can play the key role towards mitigating the economic consequences of natural and climate change disasters, and how essential it is to better quantify the beneficial effects and costs of engineer-based mitigative solutions. In this context, the legal framework, into which the actuarial quantitative model can be implemented, will support the creation of an integrated multidisciplinary approach with potential implementation on a novel platform, capable of collecting and processing information from different sources and dimensions such as blockchain technology. The scientific community is, in fact, increasingly interested in implementing blockchain technology to overcome problems linked to the contractual dimension of natural disaster risk insurance which can be interpreted as a sort of smart contracting. Through the study that involved four distinct areas, namely: law, environmental engineering, insurance and IT, this paper proposes a specific multidisciplinary methodology to achieve the drafting and implementation of a digital insurance contract on a blockchain platform against natural hazards. This paper proposes the basis to advance a quantitative concept to optimize the impact of catastrophe risk insurance onto the community resilience, in fact, providing a key synergy for definition of pre-disaster conditions.

In the article **Impact of zones with special status on the environment (experience of Russia and Kazakhstan)** by Turgel et al. (2019a) the issues of establishing and functioning of the zones with special economic activity conditions are addressed and their impact on the environment in Russia and Kazakhstan is assessed. The relevance of the subject of the research is determined, on the one hand, by a qualitative change in the role of the environmental issues in the system of values of population of the post-soviet countries and, on the other hand, by cumulative increase of the negative impact due to the irrational environmental management. It is emphasized that the current legal and regulatory framework of zones in Russia and Kazakhstan is aimed not at the prevention of environmental threats but at the easing of requirements for entities in the field of environmental management. Finally, a conclusion is made about the greening opportunities of development of the zones

with special economic activity conditions, a necessity to enhance the environmental legislation and mutual "best practices" adoption opportunities in this field in Russia and Kazakhstan.

Approaches for the organization of management of the environment protection within the framework of introduction of Smart City technologies are reviewed in **Implementation of the smart city technology for environmental protection management of cities: the experience of Russia and Kazakhstan** by Turgel et al. (2019b). For this purpose, a retrospective analysis of transformation of the Smart City notion was carried out and basic characteristics of a modern smart city interpretation were determined: the use of information technology in all functional areas of the city ecosystem, active involvement of residents in the processes of city management through organization of a system of user services, commitment to sustainable development of a city to the benefit of future generations. In the research process, the key factors of environment pollution in cities were reviewed having identified systemic challenges in the environmental field, which can be solved within the framework of introduction of the smart city concept. For each environmental factor promising technologies of the smart city system and effects that may be reached by means of their introduction are provided. In the practical part of the article, smart city's concept development and implementation experience is presented, in particular of the system elements aimed at the environmental protection in the cities of Russia and Kazakhstan.

The European Union has put competence-based teaching and competence-based education as one of the highly relevant goals. Due to mass higher education, the assessment of effectiveness and relevance evaluation of environmental engineering study programmes should become an important issue. Presently the focus of the evaluation on multi-disciplinary study programmes varies from the evaluation of attitudes, impacts or effectiveness to utilisation-focused evaluation, summative evaluation and participatory evaluation approaches. The objective of this study **Evaluation of the environmental engineering study programme at University** by Pubule et al. (2019) was to propose an effective framework to evaluate the Environmental Engineering Master study programmes, using MCA. During the research, the evaluation of existing study programmes on environmental engineering in Europe were conducted, information about the study courses, teaching methods, assessment methods and competences were used for the analysis. The results obtained showed that lectures, site visits, group coursework, practical laboratories and role-plays allows to reach the necessary knowledge, skills and competences and to provide an effective and relevant education to environmental engineering master programme students. The proposed evaluation framework was tested and approbated on new Riga Technical University master study programmes in environmental engineering and bioeconomy.

In the past few years, Colombia has begun to implement new laws according to new global trends, however, carbon dioxide emissions have not decreased despite the country's commitments according to the Paris agreement and other international treaties. In this paper **Use of multi-criteria TOPSIS analysis to define a decarbonization path in Colombia** by Diaz et al. (2019) a pathway to achieve a full decarbonization of the energy system of the country has been analysed using a multi-criteria analysis tool and considering several options from the previous studies, evaluating three different abatement scenarios obtained by different models. Then, a Strength, Weakness, Opportunities and Threats (SWOT) analysis is conducted in order to propose a set of environmental policies that aid in the seeking for a greater reduction of GHG emissions in sectors as agriculture, forestry, land use and transport. These set of measures are then summarized, and their abatement costs on GHG reduction potential are displayed. The outcomes show the country has great potential to exploit its

renewable natural resources and how a new electricity mix may not only decrease greenhouse gas emissions but also reduce the levelized cost of electricity for end users.

The article **Key factors for successful implementation of energy efficiency policy instruments: a theoretical study and the case of Latvia** by Aboltins et al. (2019) discuss that the success of energy efficiency policy depends on a number of factors, however, simultaneous application of more than just one policy instrument, coordination of multiple different policy instruments and a correct sequence of application of policy instruments are identified in research as three key factors. Energy efficiency policy instruments are very much about the most appropriate ways of overcoming a multitude of barriers to energy efficiency. Studies of energy efficiency policy instruments indicate that implementation of a single separate policy instrument will most likely fail to achieve the expected results, which in most cases is significantly improved average energy efficiency in a given country. Simultaneous implementation or combination of several policy instruments is preferable. If more than just one separate policy instrument aiming at improving energy efficiency is employed, then coordination in between the two or more policy instruments as well as correct sequence of implementation of policy instruments is essential for achieving success. Lack of or insufficient attention to a full cycle of policy analysis leads to absence of one or more of the three key factors. Decision-making about energy efficiency policy instruments becomes faulty and is based on or influenced by ad hoc decisions and random circumstances. Such an approach contributes to maintaining or amplifying existing or creating new barriers to an improved average energy efficiency and leads to a new cycle of faulty decisions unless a proper policy analysis is applied in preparing and making decisions.

The European Union has set the target for energy sector decarbonization. Variable renewable energy technologies are necessary to reach this target, but a high level of variable renewable energy raises the flexibility issues. In the research paper **Power sector flexibility through power to heat and power to gas application – system dynamics approach** by Gravelsins et al. (2019), the flexibility issue is addressed by analysing a possibility of sector coupling via power to heat and power to gas applications by using system dynamics approach. The model is applied to the case of Latvia. Model results show that power to heat is a viable flexibility measure, and with additional financial incentives, it can even help to move towards decarbonization of the energy sector. In the best scenario, the heat from surplus power can cover 37 % from the total heat production in 2050. Unfortunately, in spite of a well-developed gas infrastructure, power to gas application is still very immature, and, in the best case scenario with high incentives in power to gas technologies, only 7 % from available power surplus could be allocated for power to gas technologies in 2050.

The introduction of financial incentives for net-zero energy building/community (ZEB/ZEC) is a potential strategy that facilitates the development of sustainable buildings. In this study **Cost allocation model for net-zero energy buildings under community-based reward penalty mechanism** by Lu et al. (2019b), a reward-penalty mechanism (RPM) is firstly proposed for a community that aims to achieve the target of annual zero energy balance. In order to investigate the cost allocated for each building in the community, a cost allocation model by considering the load of these buildings and the levels of zero energy building achieved is further proposed, based on which four typical types of the model are selected and investigated. The economic performance of a building under the four types of allocation model is then compared to a community that consists of 20 family houses in Ireland. By considering the possible ZEB level ranges in each building, two Cases are conducted (Case 1 – the range is between 0.0 and 1.0; Case 2 – the range is between 0.5 and 1.0). The results show that the 1st model is the simplest one that allocates cost evenly. By contrast, the cost of

a building depends on its load in the 2nd model, and on the ZEB level it achieved in the 3rd model, while it considers the two factors evenly in the 4th model. The proposed cost allocation model is expected to provide a basic guide for the designers of financial incentives as well as experts in the fields of net-zero energy buildings.

3.5. Bioeconomy

In order to enforce the concept of bioeconomy and circular economy in the economy, the use the bottom-up approach has been proposed: to start with a small region level and to encourage their development, taking into account their specific capacities and resources, rather than generalized assumptions at a national or international level. Therefore, this study **Circular economy and bioeconomy interaction development as future for rural regions. Case study of Aizkraukle region in Latvia** by Muizniece et al. (2019) has been carried out with an aim to develop a methodology for the assessment of small rural areas in the context of the circular economy and bioeconomy, in order to advance the development of these regions in an effective way, using the existing bioresources comprehensively. The methodology is based on the identification of existing and potential bioeconomy flows (land and its use, bioresources, human resources, employment and business), the identification of the strengths of their interaction and the comparison with the situation at regional and national level in order to identify the region's current situation in the bioeconomy and the more forward-looking development directions. Several methods integrated and interlinked in the methodology – indicator analysis, correlation and regression analysis and heat maps. The methodology is approbated on one case study – Aizkraukle region – a small rural region in Latvia. During the research, recommendations for the development of the circular economy and bioeconomy for the case study have been elaborated.

Since the creation of the European Union's (EU) Biodiversity Strategy, increased attention has been drawn to the spread of invasive non-native species, their impact on biodiversity, and the economic losses caused. Ensuring compliance with the regulation on the eradication of invasive species requires financial means, therefore, a new vision on invasive plant management system is proposed. With a new system, invasive alien plant (IAP) control is ensured as well as a new source of lignocellulosic biomass for product production, that could result in financial gains is presented. This article **New vision on invasive alien plant management system** by Zihare et al. (2019) provides current alien plant situation visualization by Sankey diagram showing invasiveness of alien species and establishment, after which invasive and potentially invasive species are directed further to pre-assessment. A total of 157 invasive plant species are evaluated by multi criteria decision analysis TOPSIS, the case on the national level (Latvia) is presented and a new concept for an IAP management system is provided. The research results and the new concept provide a contribution to policy makers, land owners affected by invasive species, and municipalities.

The upcoming packaging material trend is bio-polymeric materials, since it has shown tremendous potential in practical scenarios. Even though there have been experiments performed regarding material developments, there is still no confirmation about how uncertain the developments will be. A few statistical approaches were carried out in the paper **Why biopolymer packaging materials are better** by Silva et al. (2019) to identify the role of biopolymers as a packaging material based on their thermo-mechanical and physical properties and potential, compared to other packaging materials. To determine the potential of biopolymer, it is compared with other package materials currently in demand. There are three main steps in the research. The first stage is the analysis of selected different packaging materials based on Multi-criteria decision making (MCDM) technique. The material

properties are analysed through the criteria of TOPSIS analysis. The ideal and negative ideal alternatives have been identified. Biopolymers have an outcome as the final best alternative among others. To confirm the TOPSIS results and its uncertainties, a sensitivity analysis is performed. This sensitivity analysis was performed in two phases. The first step is a regression analysis of the weighted parameters and input variables of the TOPSIS scheme. The second step is the variation of weights in a unitary variation ratio to identify the order of the TOPSIS results at each variation. Finally, all the results have concluded that the research intention has been fulfilled by performing TOPSIS and the sensitivity analysis has also confirmed this decision.

Reducing energy consumption in industry has become an important aspect on a global scale. Energy efficiency is one way of reducing energy consumption and promoting competitiveness. Increasing energy costs, security of energy supply, emissions from energy production have shown that current freezer design solutions are not sustainable. The food industry has a common tendency, whereby energy costs are only of secondary importance, unlike other production costs, resulting in minimal monitoring of energy consumption. Electricity consumption for freezer operation amounts to 20 % of total electricity consumption. Within the framework of the study **Parameters that affect electricity consumption in fish freezing. Case study** by Terehovics et al. (2019), electricity consumption for fish freezing and storing frozen fish and finished products, as well as the coefficient of performance (COP) for compressors and parameters affecting COP were analysed. From the results it can be concluded that the specific consumption of electricity in freezing of fish is lower than that of frozen fish storage. The two-stage compressor COP ranges from 2.4 to 3.7, but the single-stage compressor COP ranges from 3.7 to 5.5. The pressure in the condenser and ammonia vapor temperature after the compressor is affected by the temperature of the water used to cool the condenser and compressors. As the temperature of the water used for cooling increases, the condenser and ammonia vapor temperature after the compressor increase, which in turn reduces the compressor COP.

Bioeconomy is a target that European Union has set to be achieved; however, despite the planning documents, strategies and the financial support already given to promote it, the development of bioeconomy is slow and has not shown any significant development in the recent years. In this research **The evaluation of factors affecting bioeconomy development by using transdisciplinary approach** by Indzere et al. (2019) bioeconomy system that consists of seven factors: production, technology, climate change, infrastructure, bioresources, and pollution, is being evaluated. The selection of factors is based on literature review and opinions of the expert group. The main aim of the research is to understand which are the most influential factors within the bioeconomy system, particularly, which factors the highest attention should be paid to in the policy and strategy documents implementation on a national level. To evaluate the chosen bioeconomy system, a multi-criteria decision-making method TOPSIS was used. The TOPSIS method was performed by using transdisciplinary approach components, which emphasise the complexity of bioeconomy. The results have shown that the main three factors within bioeconomy system are bioresources, climate change and production. The least important factors are technologies and infrastructure.

The work **The role of environmental evaluation within circular economy: an application of life cycle assessment (LCA) method in the detergents sector** by Paolotti et al. (2019) aims to analyse the environmental advantages of a production process that applies to the circular economy approach. The study examines a product that is generated through the use of a certain percentage of recovered secondary materials, thus helping to avoid impacts related to the disposal of these materials and preserving ecosystems from

indiscriminate excessive natural resources extraction. The product analysed is an ecological detergent ("Ri-Detersivo" – Re-Detergent), produced by the company Tea Natura, mainly composed of regenerated vegetable oils coming from the food industry. The methodology used in this paper is Life Cycle Assessment (LCA). A partial LCA will be carried out here, arriving at the saponification phase, and comparing the environmental impacts deriving from the Re Detergent production process with those of a traditional soap, comparable to that studied in terms of function. The analysis of the case study found that the use of regenerated vegetable oils for the production of soap allows to significantly reduce the environmental impacts compared to the use of coconut oil imported from third countries.

When bioeconomy development becomes a biomass energy competitor by Lauka et al. (2019) discuss that biomass is an essential pillar of the bioeconomy as it serves as its main resource. Biomass energy plays an important role in energy sector. According to long wave theory, a sharp breakthrough in biotechnology is due over the next few years. As the price for energy wood increases, wood as a resource will not be sustainable in energy sector. In the case of Latvia, the price of energy wood as a resource is predicted to increase from 0.04 EUR/kWh to 0.12 EUR/kWh per unit of energy.

4. CONCLUSIONS

Research in environmental and climate technology becomes more and more broad and obtains new dimensions in connection with engineering, economical, social and socio-economic science.

Energy, bioeconomy, climate changes and environment nexus are observed by multidimensional approaches through different topics that present renewable energy resources, energy efficiency, policy and policy tools, waste management and bioeconomy.

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