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Sustainability Assessment of Wind Energy in Latvia: Sustainability SWOT and Multi-Criteria Analysis

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***Abstract* – Early 2020 Latvian government approved the National Energy and Climate Plan 2021 – 2030 (hereinafter - NECP2030) – a long-term energy and climate planning document setting the basic principles, goals and action lines of Latvia's national energy and climate policy for the next ten years. Although a specific target of 800 MW for wind energy development has been set, there is limited information provided on the means of achieving the wind energy target. A roadmap on wind energy development would be helpful for the stakeholders, providing a clear plan on the wind energy development, including the assessment of the most suitable form of wind energy for Latvia. The goal of this study is to propose a flexible and adaptable tool to assess, compare and select the most advantageous wind energy development alternatives for policy makers. The research goal is met by applying sustainability SWOT analysis in combination with the Multi-Criteria Decision Analysis, using the Technique for Order of Preference by Similarity to Ideal Solution. The combination of two provides a) an evaluation of comparable criteria for onshore and offshore wind energy b) assessment of the wind energy sustainability within the selected scenarios c) selection of the best possible scenario. The proposed method can help structure and lessen the complexity around the wind energy dilemma while considering economic, environment, social and technological aspects.**

***Keywords* – Assessment; comparison; multi-criteria decision analysis; National Energy and Climate Plan of Latvia; offshore wind energy; onshore wind energy; sSWOT; wind energy**

1. INTRODUCTION

Energy has always been an important part of state policy. Affordable and stable electricity is one of the main driving forces for economic growth. However, the past 20 years have changed the way electricity generation is viewed due to a number of reasons, climate change being among the most important of them. Energy is now high on global, regional and national political agendas.

The global environmental challenges have outlined a clear need for long-term planning to integrate the environmental, economic, societal and technological aspects in the process of strategizing energy systems. European Union (EU) has been a role model for the whole world for systemically setting new targets for climate change mitigation and renewable energy technology promotion.

Regulation on the governance of the energy union and climate action (EU)2018/1999 establishes a set of binding measures for the EU member states to ensure that EU climate and energy targets are met. This regulation was first introduced in 2019 and required the member states to submit their national energy and climate plans every 10 years, outlining how the EU countries intend to address energy efficiency, renewable energy sources (RES), greenhouse gas

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(GHG) emissions reductions, interconnections and research and innovation [1]. According to the Regulation on the governance of the energy union and climate action (EU) 2018/1999 'The integrated national energy and climate plans should cover ten-year periods and should provide an overview of the current energy system and policy situation. They should set out national objectives for each of the five dimensions of the Energy Union and corresponding policies and measures to meet those objectives and have an analytical basis. The integrated national energy and climate plans covering the first period from 2021 to 2030 should pay particular attention to the 2030 targets for GHG emission reductions, renewable energy, energy efficiency and electricity interconnection. Member States should aim to ensure that the integrated national energy and climate plans are consistent with, and contribute to, achieving the United Nations Sustainable Development Goals. In their integrated national energy and climate plans, Member States may build upon existing national strategies or plans' [1]. Together with the Directive on Energy Efficiency (2018/2002) EU has built the foundations for its sustainable energy policy framework up until 2030 and beyond [2].

At the end of 2019 Ministry of Economic of Latvia in consultation with other ministries and stakeholders drew up the Latvian National Energy and Climate Plan 2021-2030 (NECP2030). While it has received critics on the implementation side from the European Commission (EC) [3], NECP2030 is the only long-term energy policy planning document that sets out energy and climate targets for Latvia.

The share of energy produced from renewable energy sources (RES) in gross final energy consumption in electricity production for 2030 is set to be 50 % [4], which is likely to increase, as the EU agrees on more ambitious CO_2 reduction targets 55–60 % [5].

According to NECP2030 Latvia plans to grow the share of RES in electricity generation by increasing the installed capacity of wind power to 800 MW, given the limited availability of Latvia's electricity transmission networks, however, the document lacks clear guidance and assessment of the priority wind energy development. In the moment of writing, there is an ongoing debate between the policy makers and the Latvian Wind Energy Association (LWEA) on the focus for the type of wind energy development in Latvia. On one hand the Latvian Minister for Economics and the Estonian Minister for Economic Affairs and Infrastructure have signed a memorandum of understanding aimed at the development of an offshore wind farm by the two states; on the other LWEA statements call on the government to support faster onshore wind energy development in Latvia.

To the author's knowledge, there have not been studies carried out assessing and comparing the benefits and disadvantages of developing onshore and offshore wind in Latvia.

2. METHODOLOGY

The main objective of this paper is to assess the two types of renewable energy in Latvia – onshore and offshore and to offer a recommendation to policy makers that could potentially help in shaping the renewable energy future in Latvia.

Looking at the Latvian NECP2030, the policy makers have highlighted the necessity to grow the share of renewable energy in the total energy generation until 2030. Among the local resources which have been underutilised NECP2030 points out wind energy. This document outlines both the need for onshore and offshore wind energy, however, it is inconclusive as to where the priority should lie [4]. The recently signed memorandum of understanding between Latvia and Estonia with an aim to assess various sites in the Baltic Sea for wind farm construction and the public relations campaign that followed the event could be perceived as a signal of prioritising offshore wind energy by the Latvian government.

By assessing and comparing both wind energy types in terms of various aspects of their performance, the author intends to obtain result that could give substantial arguments in defining the renewable energy policy focus. The assessment of onshore and offshore wind energy is done using the combination of sustainability strengths, weaknesses, opportunities and threats (sSWOT) analysis and multi criteria decision analysis (MCDA). Fig. 1 illustrates the conceptual scheme of the methodologies used in this paper; both methods together.

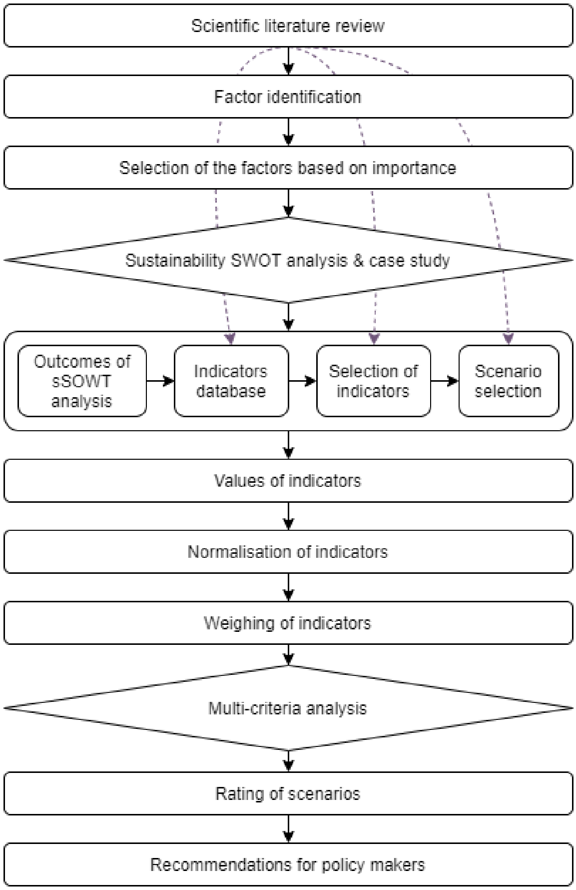


Fig. 1. Concept of the overall methodology.

2.1. SWOT and sSWOT

SWOT analysis is a widely used method to help both organisations and governments formulate their strategies and foresee the emerging challenges. All four elements need to be looked at and identified in order to formulate and implement a strategy to achieve the planned goals. Moreover, assessment of the organisation's internal and external environment is a crucial element for the strategic planning process. The results of the SWOT analysis can give a good idea on the internal resources and their relations to the external environment [6].

The objective of the SWOT analysis is to group the available information into internal and external factors. Strengths and weaknesses belong to internal factors, whereas opportunities and threats are external. Once the factors have been identified and added to the SWOT matrix, it can help organisations and governments see where the attention is needed and to come up with strategies on how to mitigate threats and weaknesses [7].

To better understand the four elements of SWOT when applying them to government policies, it is important to comprehend the definitions of them: 'Strengths stand for any available resources that can be used to advance the performance. Weaknesses are flaws, which may decrease competitive advantages, efficiency, or financial resources. Opportunities are external changes that could contribute to an additional development and threats are outside factors that may cause problems' [8].

When looking specifically at renewable energy policies, a more thorough SWOT method is used – sustainability SWOT (sSWOT). The World Resources Institute (WRI) created this type of analysis to initially help companies to tackle environmental challenges by pushing organisations to engage departments and decision makers into more sustainable choices.

An sSWOT is a new spin on the already familiar strategic SWOT analysis framework. It can be used as well as in private holdings as in renewable energy planning [9]. A significant difference from the classical SWOT analysis is the starting point. While SWOT dives right into analysing strengths, weaknesses etc., sSWOT initiates with the global dimension addressing the long term global environmental and social challenges. Authors Tahseen, S. and Karney, B. in their work 'Opportunities for increased hydropower diversion at Niagara: An sSWOT analysis' have summarised the true meaning of sSWOT analysis in a brilliant sentence: 'The sSWOT analysis connects long-term environmental and social challenges with economic priorities and can communicate new policy insights' [10].

Additionally, *Threebility* sSWOT model suggests to not only think about the challenges but also to add a context to the discussed topic. It invites to consider a sustainability relevant trends such as major political, economic and environmental shifts. Table 1 illustrates the sSWOT model.

TABLE 1. sSWOT ANALYSIS MODEL

Environmental & Social Challenges & Big Trends	Strengths, Opportunities, Weaknesses & Threats		Prioritization & Action
Challenges	S Strengths	W Weaknesses	Prioritise
Trends	O Opportunities	T Threats	Action

2.2. Multi-Criteria Decision Analysis (MCDA)

The multi-criteria analysis compares 2 or more alternatives selected based on the results of the sensitivity analysis. The aim of multi-criteria analysis is to evaluate and compare the viability and sustainability of the chosen alternatives. MCDA is widely used in energy policy decision making. When choosing the alternatives in the MCDA one should take into account a number of different aspects at different levels: economic, technical, social, and environmental [11]. Multi-criteria analysis tool allows to integrate and evaluate all possible outcomes related to the decision-making process, by establishing a relationship between all alternatives and factors that influence the decision [12]. It can provide a technical-scientific decision-making support tool that is able to justify its choices clearly and consistently in the renewable energy sector.

Multi-criteria analysis helps decision makers carefully weigh the various difficult to compare criteria. Creating such analysis entails a 'decision matrix' which is done for each criterion assigning a certain 'weight'. There are usually 8 steps in the MCDA:

1. Problem identification;
2. Identification of alternatives;
3. Criteria identification;
4. Evaluation of alternatives with points after certain criteria;

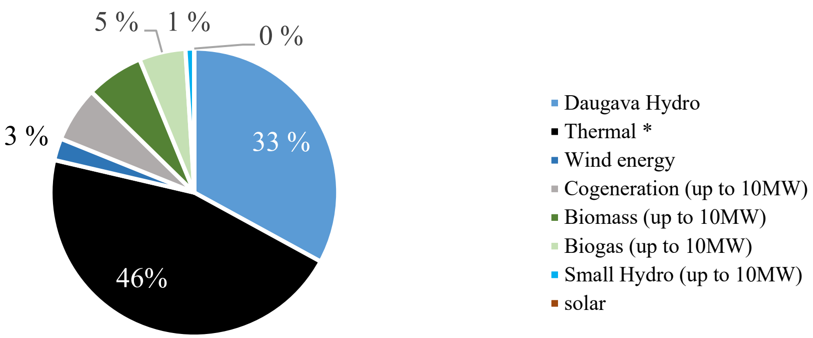
5. The criteria are weighted according to importance;
6. Comparison of alternatives;
7. Sensitivity and risk analysis (feedback dynamics);
8. Arrangement of alternatives and final decision [12]–[14].

3. Case Study

3.1. Energy History in Short

The first megawatts of wind energy were installed around 20 years ago, when Latvia introduced a complex RES support system based on a feed-in tariff together with elements of tenders and quota system. It gave a boost to wind installations totalling to 78.6 MW [15]. This number hasn't changed for the past 10 years and thus is still the official statistic of Latvia in 2020.

The local electricity generation by source can be viewed in the Fig. 2. The net electricity consumption in Latvia in 2019 totalled 7 297 056 MWh [16].



* Riga TEC-1, Riga TEC-2, AS 'Rīgas Siltums', SIA 'Juglas Jauda', SIA 'Fortum'

Fig. 2. Electricity generation in Latvia in 2019 [17].

The total electric energy consumption in Latvia is 7.3 TWh out if which 6.18T Wh is generated locally and 1.12 TWh are imported from neighbouring countries. The pie chart in Fig. 3 shows the proportion of locally generated electricity versus imported. It is important to emphasise that out of the 85 % which corresponds to local generation, 45 % (2.82 TWh) is energy produced in thermal power plants using imported fossil energy – natural gas [17].

When Latvia joined the EU in 2004, a gradual process of adapting the EU legislation continued. Latvia created a support scheme for renewable energy and cogeneration based on the feed in tariff. The feed in tariff guaranteed that the renewable energy and producer and the producer of electricity from cogeneration may acquire the right to sell the electricity through mandatory procurement [18]. However, as of 2016 the feed-in tariff has been suspended. New RES generations are no longer able to benefit from the feed-in tariff, while the previously contracted (up until 2016) RES and cogeneration plants still get their support paid within the framework of mandatory procurement. The end date for the support paid to the procurers depend on individual contracts.

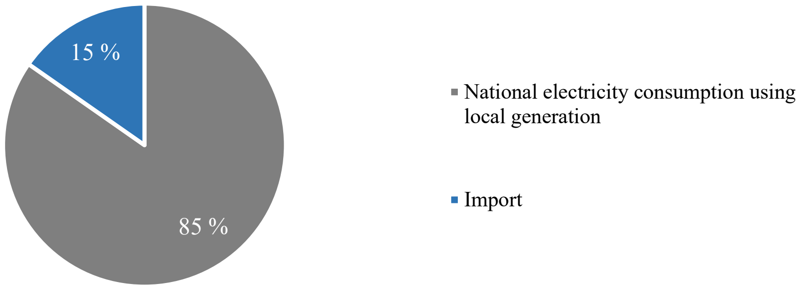


Fig. 3. Electric energy generation and imported energy in Latvia in 2019.

3.2. Wind Energy in the National Energy and Climate Plan

Latvia's National Energy and Climate Plan 2021–2030 (NECP) is a document for the long-term planning of energy and climate policy laying down the basic principles, goals and action lines of Latvia's national energy and climate policy for the next ten years.

The policy makers have indicated in the NECP that wind energy is the likely to reserve the 800 MW of the grid availability, as the modern onshore and offshore machines are among the most suitable renewable energy technologies for Latvia. Moreover, when assessing NECP, it important to look at the two offered renewable energy development scenarios: a) base scenario, b) target scenario [4].

While the base scenario foresees the share of electricity from RES growing to 50 % by 2030, in the target scenario, the amount of electricity generated from the RES increases much more significantly. The increase is forecasted mainly due to wind turbines, but there is also a small increase in electricity produced from solar power plants. In 2030, the share of electricity generated from RES could reach at least 67 %. It is secured by hydropower plants, all types of biomass cogeneration plants and wind power plants.

The ministry of Economics emphasizes in the NECP document the role of the regional opportunities for cooperation in the field of RES and their technologies. In particular the emphasis lays on the possible joint development of offshore wind farms, taking into account maritime spatial planning considerations, which allow joint projects to be developed on the Latvian-Estonian border and on the Latvian-Lithuanian border. NECP points out that joint offshore wind parks with a maximum capacity of 800 MW could be installed in the next 10 years, however the document also states that there is a list of policies and measures to be implemented in order to enable such development.

While EU has announced in its EU strategy on offshore renewable energy COM(2020) 741 plan to boost the offshore wind energy within the next 30 years through allocation of various funds and mechanism [19], onshore wind still remains the cheapest form of renewable energy. Hence it can be questioned, whether the offshore wind energy technologies at this stage are in fact the most cost-effective between the two.

3.3. sSWOT Analysis of Wind Energy Potential in Latvia

Wind energy has played a vital role in transitioning Europe and other economies towards decarbonisation of their energy systems. In 2019 wind produced 1404 TWh of electric power within Europe alone. However, coal, natural gas and other fossil fuels still supplying 62 % of the world's electricity, coal being the largest share of the fossil fuels [20].

Besides the obvious benefit of reducing CO_2 emissions, wind power can also play a crucial role in boosting local economies through direct investment inflow and taxes. Latvian Wind Energy Association estimates that wind power sector in Latvia could attract more than 350 million EUR within the next 5 years. Investment also means jobs, as construction process of wind farms makes up to 25 % of the total project costs, income to land owners and local communities, new road infrastructure and many others [15].

To summarise the above described, the benefits of wind energy can be considered the STRENGTHS block in the sSWOT analysis. WEAKNESSES represent the wind energy challenges in Latvia. OPPORTUNITIES and THREATS outline the possible future paths, and TRENDS and CHALLENGES describe the global context of renewable energy technologies. Table 2 list the above-mentioned factors impacting wind energy development locally and on the global scale.

3.4. Multi-Criteria Decision Analysis – TOPSIS Approach

Based on the result from sSWOT analysis, a set of important factors have been obtained helping assess wind energy's various aspects.

The most important factors are then selected and fed into the TOPSIS model at the same time choosing the possible scenarios of the offshore development in Latvia.

As mentioned before there are no new onshore or offshore wind farms in Latvia, preventing the author from selecting precise values for the chosen criteria. Hence general values are used based on the data available at various statistics reports provided by authoritative international institutions such as International Energy Agency, International Renewable Energy Agency, WindEurope and Global Wind Energy Council. The values of criteria are projected to match the 800 MW of installed wind energy capacity (target set in the Latvian NECP).

After consultations with experts in a field, 5 scenarios have been selected:

1. 100 % onshore wind energy, 800 MW;
2. 100 % offshore wind energy, 800 MW;
3. 50 % onshore, 400 MW; 50 % offshore wind energy, 400 MW;
4. 40 % offshore, 320 MW; 60 % onshore wind energy, 480 MW;
5. 60 % onshore, 480 MW; 40 % offshore wind energy, 320 MW.

Table 3 and 4 outlines the table with 10 criteria and 5 different scenarios, normalised decision matrix and weighted decision matrix.

Additionally, the weights of the criteria have been given according to the expert opinions - wind farm developers, academics and people living in local municipalities and wind energy survey data.

TABLE 2. sSWOT ANALYSIS

STRENGTHS	WEAKNESSES
From the perspective of a society: – Development of the most cost-effective electricity generation technology; – Competition drives the electricity price down - cheaper electricity for Latvian consumers; – Lower electricity price will increase the demand for it, promoting industrial competitiveness and increasing the demand for other sustainable technologies - heat pumps for heating, electric transport, hydrogen; – More efficient utilization of the ready-made energy system will help to drive down the infrastructure costs of transmission and distribution costs; – Increasing energy independence; – Electricity as an important export commodity; – Important contribution to achieving renewable energy targets with the most economically viable solution; – Inflow of foreign direct investment in Latvia; – Economic value through increase of jobs – 20–25 % of the investment is spent locally - construction works, services and consultations [21]; – Additional income for landowners - physical persons, organisations, government institutions; – Budget revenue through taxes; – Best practices show that wind project pay contributions to funds managed by local communities. **From the perspective of a developer:** – Good wind conditions; – Territory (land and sea); – Developed power transmission network (also network integration with the region); – Pro-renewable energy government.	– Lack of political will, lack of understanding among policy makers on national and local level (lack of motivation); – Subsidies for fossil energy; – Lack of motivation to open up forest lands for wind turbine development; – Lack of clear communication from the policy makers about the benefits of wind energy [22]; – Lack of market and permitting information for foreign investors (one stop shop); – Changing policy environment (G-component) which has a large impact on wind project bankability [23]; – Termination of RES support schemes; – Obsolete legal framework for wind energy development (Regulation of the Cabinet of Ministers No. 240 (was amended in the process of writing this paper) and No. 883); – Long and heavy permitting process; – Lack of binding regulations for wind turbine parameters (infrasound, icing, flickering); – Lack of legal framework for energy communities [24]; – Lack of research for wind energy impacts in Baltic sea; – Outdated/irrelevant regulatory framework for offshore wind energy; – Municipal veto rights late at the project planning phase (municipalities can block projects after they have undergone the environmental impact assessment and have received a positive opinion from the Environment State Bureau) [25]; – Limited building areas due to proximity to: Farmsteads (scattered in Latvia); Natura 2000 territories and micro reserves; Limitations to build wind turbines on national and local significance agricultural land; – Resistance from local communities: Fear of new technologies; Fear of health and environmental impacts; Targeted myth spreading by anti-wind interest group; Nimby effect; – Lack of motivation on municipal level
OPPORTUNITIES	**THREATS**
– Further increase of deployment of onshore wind power; – Deployment of offshore wind energy; – Further technology improvements resulting in better acceptance by municipalities; – Clear legal framework developing wind project using best available technology; – Reduction of greenhouse gas emissions; – Improved energy security through diversification and decentralisation of electric power generation.	– Growing unjust market conditions (state supporting fossils through hidden subsidies). Risk of delaying deployment RES, especially wind energy; – Variable legal framework increasing the investment risk factors and reducing wind project bankability rates; – Disadvantageous (compared to neighbouring countries) market conditions;
GLOBAL CLIMATE CHALLENGES	**GLOBAL CLIMATE TRENDS**
– Climate change and greenhouse gas reduction targets; – Air quality; – Resource scarcity.	– Innovation & technology advances; – Political framework for economy greening.

TABLE 3. NORMALIZED DECISION-MAKING MATRIX AND WEIGHTS

		rai₁	***rai₂***	***rai₃***	***rai₄***	***rai₅***	**Weight (based on expert opinion)**
		100 % Onshore	100 % Offshore	50 % onshore; 50 % offshore	40 % offshore; 60 % onshore	40 % onshore; 60 % offshore	
LCOE	EUR/kWh	0.25	0.61	0.43	0.40	0.47	0.11
Weighted average total installed costs	EUR/kW	0.22	0.69	0.40	0.37	0.43	0.12
Capacity factor	%	0.40	0.49	0.45	0.44	0.46	0.11
Energy output/ year/ 800 MW	GWh	0.37	0.52	0.45	0.43	0.46	0.12
Sound power	db	0.35	0.47	0.47	0.47	0.47	0.08
CO_2 saving from 800 MW	metric t/year	0.37	0.52	0.45	0.43	0.46	0.12
Community investment possibility	10 – yes, 0 – no	0.75	0.08	0.37	0.45	0.30	0.08
Perceived impacts	%	0.64	0.20	0.43	0.47	0.37	0.04
Jobs / 800 MW	number	0.24	0.62	0.43	0.40	0.47	0.11
Income to land owners / 800 MW	EUR	0.42	0.48	0.45	0.44	0.45	0.11

TABLE 4. WEIGHTED DECISION-MAKING MATRIX

		vai₁	***vai₂***	***vai₃***	***vai₄***	***vai₅***
		100 % Onshore	100 % Offshore	50 % onshore and 50 % offshore	40 % offshore and 60 % onshore	40 % onshore and 60 % offshore
LCOE	EUR/kWh	0.03	0.07	0.05	0.04	0.05
Weighted average total installed costs	EUR/kW	0.03	0.08	0.05	0.04	0.05
Capacity factor	%	0.04	0.05	0.05	0.05	0.05
Energy output/ year/ 800 MW	GWh	0.05	0.06	0.05	0.05	0.06
Sound power	db	0.03	0.04	0.04	0.04	0.04
CO_2 saving from 800 MW	metric t/year	0.05	0.06	0.05	0.05	0.06
Community investment possibility	10 – yes, 0 – no	0.06	0.01	0.03	0.04	0.02
Percieved impacts	%	0.03	0.01	0.02	0.02	0.02
Jobs / 800 MW	number	0.03	0.07	0.05	0.04	0.05
Income to land owners / 800 MW	EUR	0.05	0.05	0.05	0.05	0.05

4. Results

The results of TOPSIS method showed that the scenario of 100 % onshore wind energy scores the highest with the closeness to the ideal solution (Ca) value of 0.648, being the closest to the Positive Ideal Solution. Second best results show the scenario with the least offshore wind energy percentage and the most onshore in it. Subsequently, offshore wind energy scenario is closest to the Negative Ideal Solution. Full set of results can be viewed in Fig. 4.

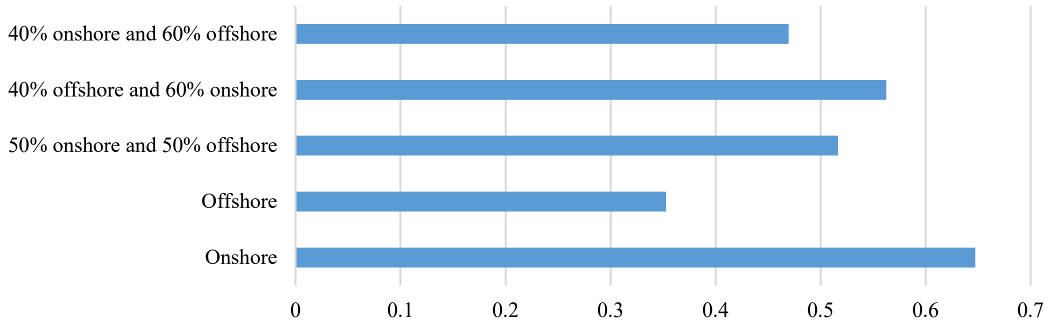


Fig. 4. Multi-criteria decision analysis (MCDA).

As the following step a sensitivity analysis was performed highlighting the dependence of relative closeness to the ideal solution on the weight (or importance) of criteria.

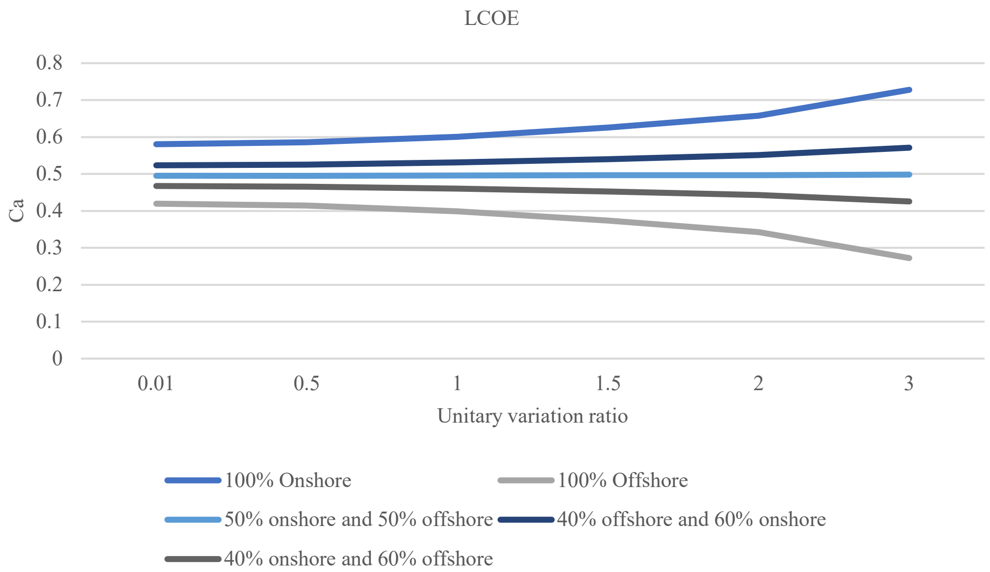


Fig. 5(a). Sensitivity analysis of LCOE.

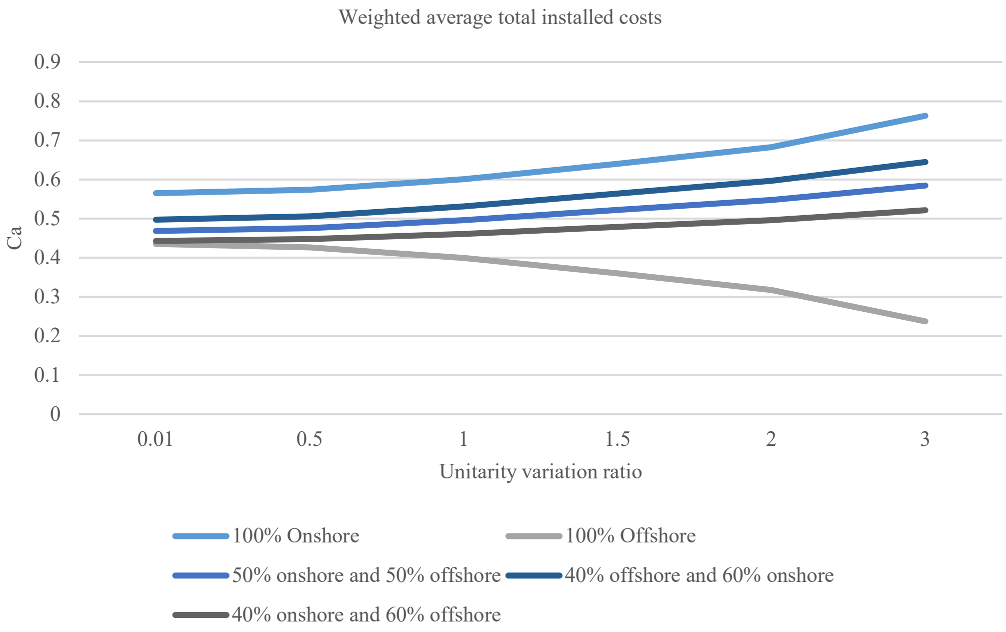


Fig. 5(b). Sensitivity analysis of Weighted average total installed costs.

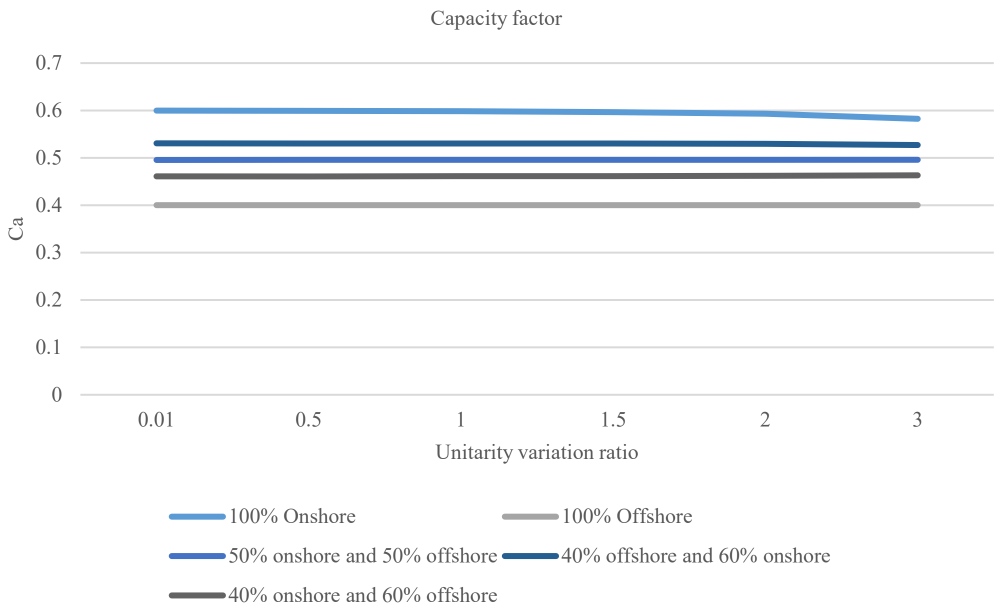


Fig. 5(c). Sensitivity analysis of Capacity factor.

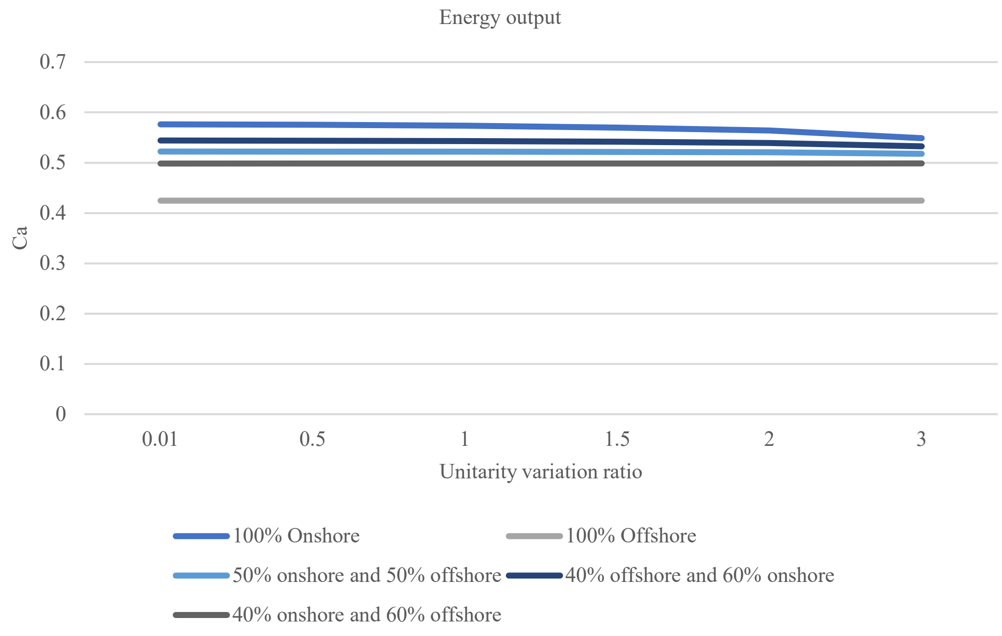


Fig. 5(d). Sensitivity analysis of Energy output .

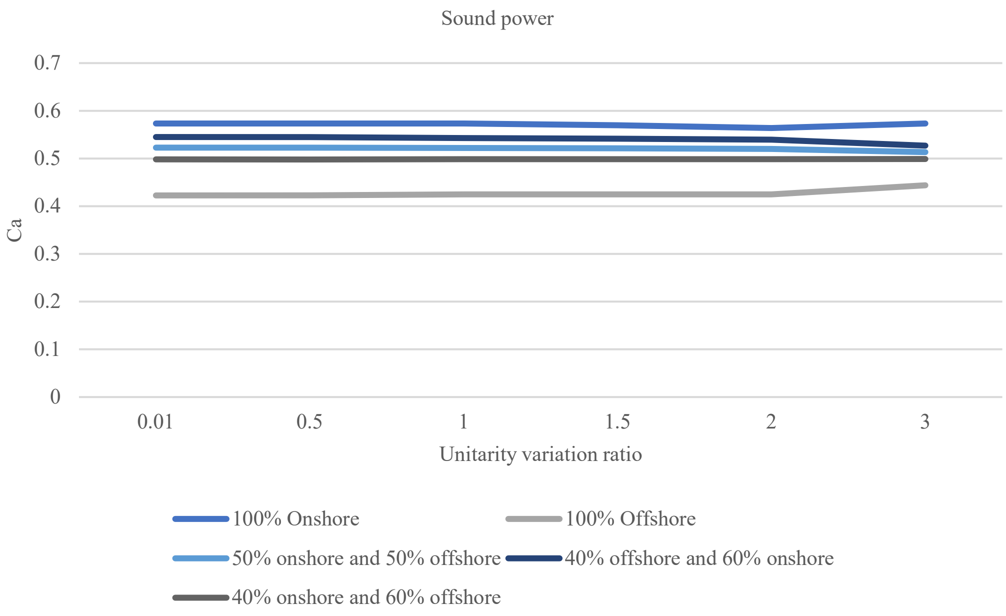


Fig. 5(e). Sensitivity analysis of Sound power.

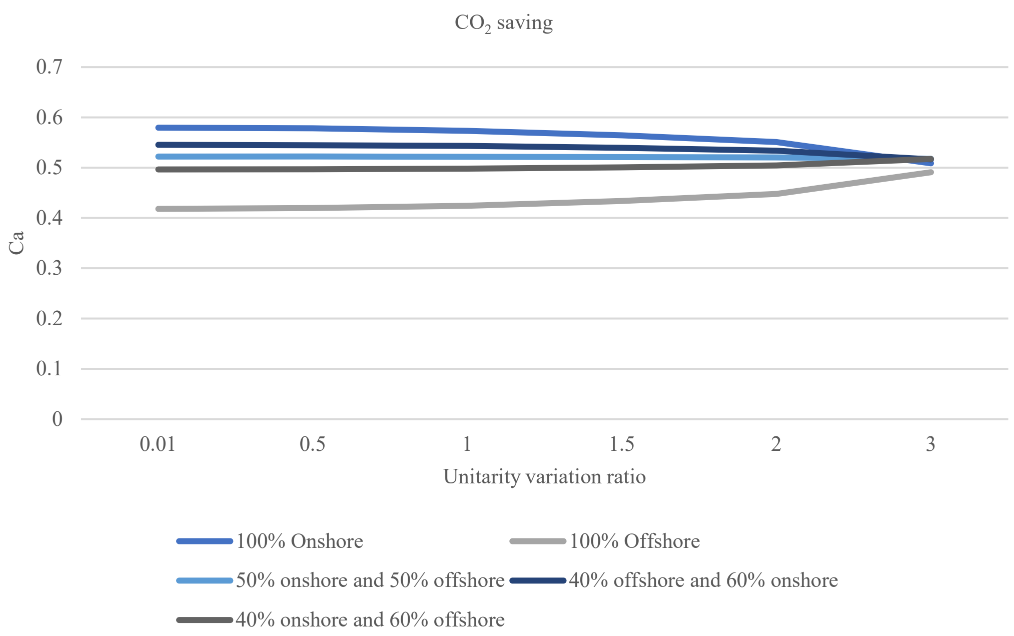


Fig. 5(f). Sensitivity analysis of CO_2 saving.

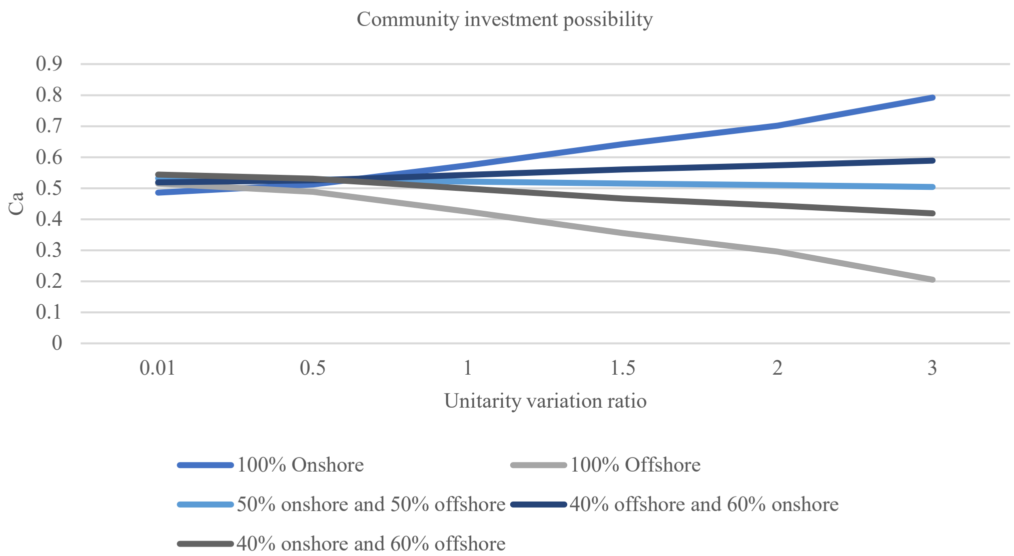


Fig. 5(g). Sensitivity analysis of Community investment possibility.

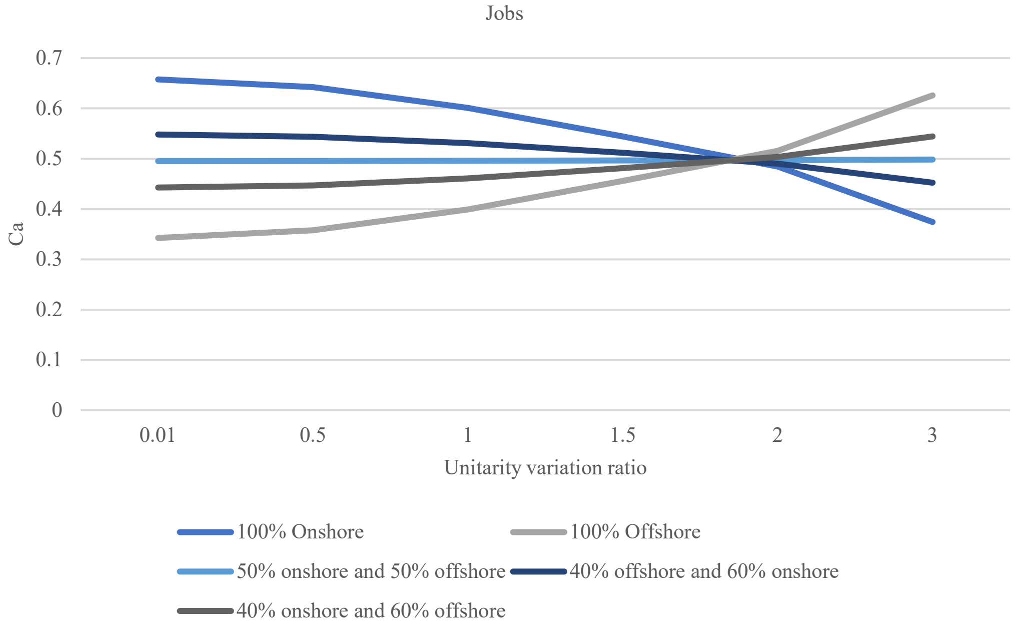


Fig. 5(h). Sensitivity analysis of Jobs.

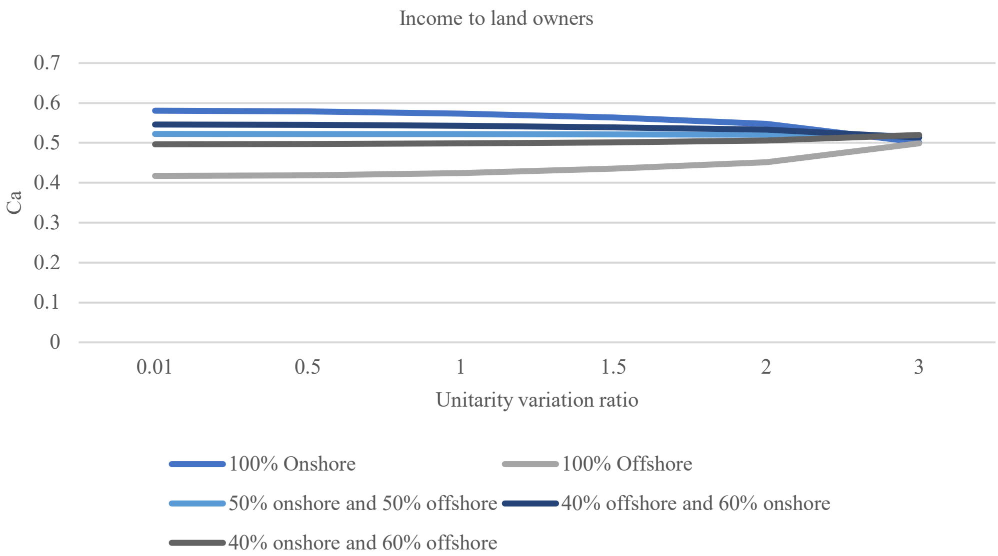


Fig. 5(i). Sensitivity analysis of Income to land owners.

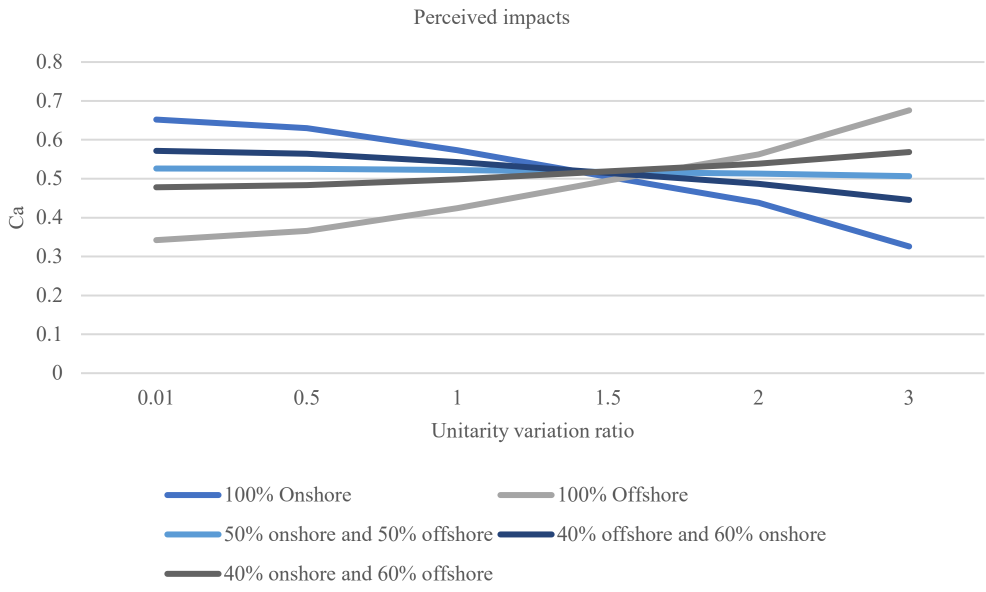


Fig. 5(j). Sensitivity analysis of Perceived impacts.

According to the sensitivity graphs Figs. 5(a, b, c, d, e, f, g, h, i, j) criteria most depend on their weight in the cases of levelized cost of electricity, jobs and community investment possibilities, as their variation ratio starts changing close to the value 0.05.

5. Conclusion

Wind energy is important in decarbonising European economies. Although wind energy will probably not replace gas-fired CHPs in the next 5 years in Latvia, especially to provide district heating. But wind energy can certainly be part of flexible solution like wind power and storage for electricity generation and wind turbines in combination with heat pumps for centralised and individual heating [26].

The ongoing debate in Latvia on the preferred wind power type – onshore or offshore – has been topical among policymakers, industry and local communities. The focus is unclear, as the Latvian National Energy and Climate plan does not draw clear scenarios for onshore and offshore wind other than setting an 800 MW target. Future research on use of near shore/coast options should be done.

The performed sSWOT analysis in combination with MCDA using TOPSIS approach, confirms the suitability of onshore wind energy as the best possible option for Latvia. Based on the selected ten wind energy describing factors or criteria in five different scenarios, the analysis concludes that at this point of time under these specific economic and political conditions the preferable choice for electricity generation among two means of wind power would be onshore wind energy.

The MCDA assessment model provides a framework for further development, as more criteria can and should be added to it and the weights can be re-assigned differently to increase the accuracy of analysis. This model already provides good basis for evaluating wind energy from different aspects (economic, social, technological, environmental) and can be used by policy makers in helping of the process of formulating future energy policies.

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REFERENCES

[1] European Commission. REGULATION (EU) 2018/1999 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 11 December 2018 on the Governance of the Energy Union and Climate Action, amending Regulations (EC) No 663/2009 and (EC) No 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) No 525/2013 of the European Parliament and of the Council. *Official Journal of the European Union* 2018:61:L 328.

[2] European Parliament, Council. DIRECTIVE (EU) 2018/2002 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 11 December 2018 amending Directive 2012/27/EU on energy efficiency. *Official Journal of the European Union* 2018:L 328/210.

[3] European Commission. Assessment of the final national energy and climate plan of Latvia (EN). Brussels: EC, 2020.

[4] Ministry of Economics of the Republic Of Latvia. National Energy and Climate Plan 2021-2030. Riga: ME, 2019.

[5] Simon F. EU Parliament votes in favour of cutting emissions 60% by 2030. Climate Change News [Online]. [Accessed 1.11.2020]. Available: https://www.climatechangenews.com/2020/10/07/eu-parliament-votes-favour-cutting-emissions-60-2030/

[6] Nikolaou I., *et al.* An evaluation of the prospects of green entrepreneurship development using a SWOT analysis. *International Journal of Sustainable Development & World Ecology* 2011:18:1–16. https://doi.org/10.1080/13504509.2011.543565

[7] Terrados J., *et al.* Regional energy planning through SWOT analysis and strategic planning tools.: Impact on renewables development. *Renewable and Sustainable Energy Reviews* 2007:11(6):1275–1287. https://doi.org/10.1016/j.rser.2005.08.003

[8] Chen W. M., *et al.* Renewable energy in eastern Asia: Renewable energy policy review and comparative SWOT analysis for promoting renewable energy in Japan, South Korea, and Taiwan. *Energy Policy* 2014:74:319–329. https://doi.org/10.1016/j.enpol.2014.08.019

[9] Metzger E., *et al.* sSWOT - A Sustainability SWOT. Washington: World Resources Institute, 2012.

[10] Tahseen S., Karney B. Opportunities for increased hydropower diversion at Niagara: An sSWOT analysis. *Renewable Energy* 2017:101:757–770. https://doi.org/10.1016/j.renene.2016.09.041

[11] Diakoulaki D., Karangelis F. Multi-criteria decision analysis and cost-benefit analysis of alternative scenarios for the power generation sector in Greece. *Renewable and Sustainable Energy Reviews* 2007:11(4):716–727. https://doi.org/10.1016/j.rser.2005.06.007

[12] Abu Taha R., Daim T. Multi-Criteria Applications in Renewable Energy Analysis, a Literature Review. Research and Technology Management in the Electricity Industry. London: Springer, 2013:60:17–31. https://doi.org/10.1007/978-1-4471-5097-8

[13] Tzeng G.-H., Huang J.-J. Multiple Attribute Decision Making. Boca Raton: CRC, 2011.

[14] Wojciech S. Normalization of attribute values in TOPSIS method. Nowe Trendy w Naukach Inżynieryjnych. New York: CreativeTime, 2014:179–186.

[15] Vanags A., Delfi. Vai protam pieņemt lēmumus, domājot par nākotnes interesēm? (Do we know how to make decisions with future interests in mind?) [Online]. [Accessed 13.12.2020]. Available: https://www.delfi.lv/bizness/versijas/andris-vanags-vai-protam-pienemt-lemumus-domajot-par-nakotnes-interesem.d?id=52096587 (in Latvian)

[16] Augstsprieguma Tīkls. Pārvades sistēmas operatora ikgadējais novērtējuma ziņojums par 2019.gadu (Annual evaluation report of the transmission system operator for 2019.). Riga: AST, 2020. (in Latvian)

[17] Augstsprieguma Tīkls. Latvian Electricity Market Overview [Online]. [Accessed 6.03.2021]. Available: https://www.ast.lv/lv/electricity-market-review

[18] Spruds A. Latvian energy policy: towards a sustainable and transparent energy sector. Riga: Soros Foundation-Latvia, 2010.

[19] European Commission. Communication From The Commission To The European Parliament, The Council, The European Economic And Social Committee And The Committee Of The Regions: An EU Strategy to harness the potential of offshore renewable energy for a climate neutral future. Brussels: 2020.

[20] Collins L. Recharge News. Global wind and solar energy growth rate in 2019 was 'slowest this century'. [Online]. [Accessed 06.03.2021]. Available: https://www.rechargenews.com/wind/global-wind-and-solar-energy-growth-rate-in-2019-was-slowest-this-century/2-1-769738
[21] Martin J., Ramsey D. The economics of wind energy. *Applied Corporate Finance* 2009:21(2):100–109. https://doi.org/10.1111/j.1745-6622.2009.00231.x
[22] Hinsch A., *et al.* A WinWin(d) for all. The handbook for socially inclusive wind energy. Berlin: WinWind, 2020.
[23] Iljinska K. Forbes Baltic. Latvija savu konkurētspēju mazinās, ieviešot G komponenti vēja enerģijas ražotājiem (Latvia is reducing its competitiveness by introducing G components for wind energy producers.). [Online]. [Accessed 15.04.2021]. Available from: https://forbesbaltics.com/lv/zinas/raksts/g-komponente
[24] Rīgas Plānošanas Reģions. Rokasgrāmata kopienu atjaunīgo energoresursu projektu ieviešanai Latvijā (Handbook for the implementation of community renewable energy projects in Latvia.). Riga: RPR, 2020. (in Latvian)
[25] Pubule J., *et al.* Analysis of the environmental impact assessment of power energy projects in Latvia. *Management of Environmental Quality* 2012:23(2):190–203. https://doi.org/10.1108/14777831211204930
[26] Aboltins R., *et al.* Vēja enerģijas izmantošanu ietekmējošo faktoru analīze un iespējamie risinājumi. Riga, 2019.