OPTIMIZATION OF IMPLEMENTATION PROCEDURES FOR RES ELECTRICITY GENERATION INFRASTRUCTURE PROJECTS IN THE BALTIC STATES, NO. EM 2021/19

Comparison of the implementation processes of RES electricity generation infrastructure projects

2021

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1. METHODOLOGY FOR RES PROJECT IMPLEMENTATION PROCESS COMPARISON

1.1. Criteria for comparison

The purpose of the comparison of the procedure for the implementation of RES electricity generation infrastructure projects in different Baltic and Nordic countries is to:

- compare the formal procedures, permitting process, other requirements, including spatial planning conditions and procedures, environmental impact assessment, as well as barriers which hinder the implementation of RES electricity generation infrastructure projects;
- assess the critical points in the procedures needed for implementation of renewable energy power generation projects;
- identify examples of good practice;
- Provide conclusions on the procedure for implementing RES electricity generation infrastructure projects in Latvia, Lithuania, and Estonia.
- Develop recommendations for more straightforward coordination procedures for RES electricity generation infrastructure projects, facilitating administrative procedures and removing obstacles.

The comparison is performed based on defined and harmonised criteria for comparing administrative systems to implement RES electricity generation infrastructure projects. Five main criteria have been identified for procedure comparison (shown below). In addition, the implementation process has been compared from different perspectives by considering the timeline, complexity, information availability, impact of public opinion, and local authorities (municipalities). Each of the analysed criteria includes one or several sub-criteria, described below.

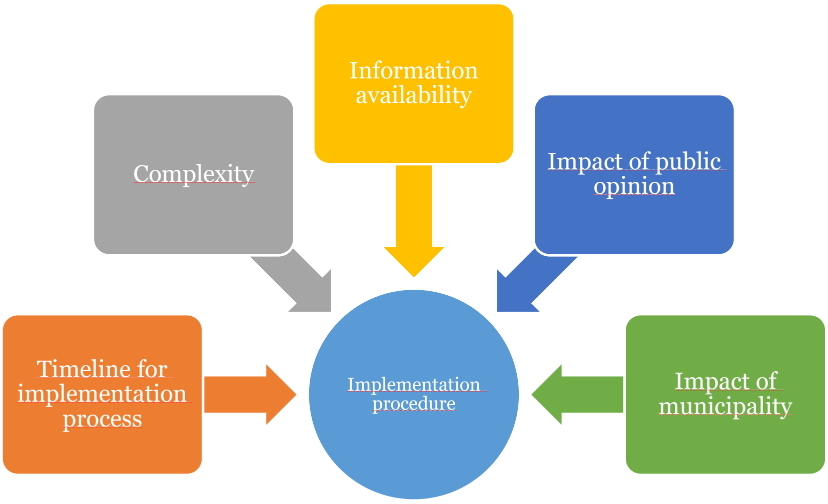

Fig.1.1. Primary criteria for comparing implementation procedures for RES power generation infrastructure projects in different countries

The comparison has been prepared to assess separately different technological solutions of power production:

- microgeneration;
- large and average scale solar power systems;
- large and average scale wind power projects;
- offshore wind projects.

1.1.1. Timeline of the implementation process

The Directive, 2018/2001 of the European Parliament and of the council of December 11, 2018, on the promotion of the use of energy from renewable sources (further "RES Directive"), sets a maximum time limit for the implementation procedure for RES projects (European Parliament and the European Council, 2018). It is specified that the authorisation process shall not exceed two years for procedures applicable to power plants, including all relevant procedures of the competent authorities (European Parliament and the European Council, 2018). In well-grounded exceptional circumstances, the two years may be extended for a further period of up to one year (European Parliament and the European Council, 2018). The permitting process for installations with an electricity generation capacity of less than 150 kW shall not exceed one year (European Parliament and the European Council, 2018). In well-grounded exceptional circumstances, the two years may be extended for a further period of up to one year (European Parliament and the European Council, 2018).

An analysis of the administrative procedures was carried out to determine whether the implementation procedure of wind and solar projects in the Baltic and Nordic countries complies with the RES Directive. If necessary, the analysis is based on the national legislation and regulatory documents, with additional information on the process obtained from the authorities' websites. For more detailed information on the research carried out, the administrative processes identified, and the literature sources, see the first two parts of this research, "Current situation in the process of implementation of RES electricity generation infrastructure projects in Latvia, Lithuania and Estonia" and "Analysis of the implementation processes of RES electricity generation infrastructure projects in Finland, Norway and Sweden". In addition, the information gathered in the first two phases of this study was collated and compared to determine the length of the approval process for renewable energy projects in the countries included in the study to determine whether the duration of the process as set out in the RES Directive is being followed.

During the previous stages of the study, it became clear that some project implementation permitting procedures are project-specific and depend highly on local conditions and project developers (Abranches et al., 2020; Valença & Bernard, 2015). The timeline is therefore analysed separately for processes with standardisable and clearly definable rules under the legislation and the application procedure and separately for non-standardisable permit or consent procedures which take into account various project-specific criteria, as well as the developer's own ability to meet the requirements set by the authorities on time. Furthermore, the progress of non-standardisable procedures is strongly influenced by the different conditions and factors that require additional time to be considered.

Three main sub-criteria have been identified for the process analyses:

- **Time for standardisable process steps;**
- **Time for non- standardisable process steps (with many variables);**
- **Total time for project implementation.**

Fig.2. shows that permit for increasing electricity production capacities or the introduction of new production equipment, construction permits and electricity trading permits are standardisable processes with predictable variables and a fixed timeframe for implementation. These permits are issued by the government ministries or state agencies responsible for the sector and local authorities. The duration of the process depends mainly on the authorities' capacity but should not exceed the number of days (usually 30-70 days)

stipulated in the regulatory documents. The timeframes for processing applications and issuing the relevant permits have been identified in the previous two phases of the study through an analysis of regulatory documents and the authorities' websites.

Processes such as environmental impact assessment, spatial planning changes and grid connection are project-specific, requiring additional experts such as ornithologists, bat researchers, planners, and landowners in the vicinity to meet requirements and obtain approvals. Therefore, these processes are described as "non-standardisable" because, despite the regulatory time frames for examining applications and granting approvals, they will vary slightly from project to project (Gulbrandsen et al., 2021; Schütz & Slater, 2019). Nevertheless, the timeframes for processing applications and issuing the relevant permits have been identified in the previous two phases of the study through an analysis of regulatory documents and the authorities' websites.

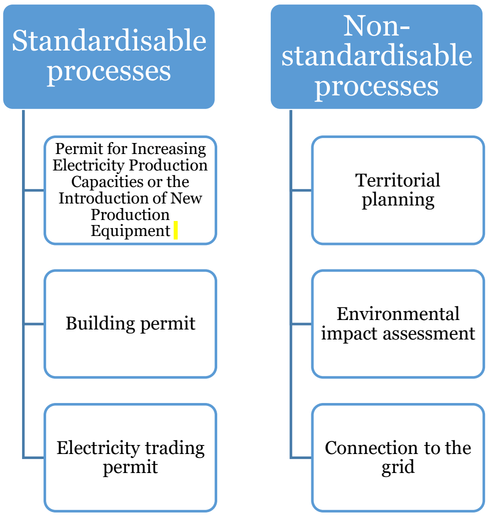

Fig.1.2. Timeline analyses depending on the implementation process

In addition to the identified project implementation timeframe for "standardisable" and "non-standardisable" processes, the total project implementation time was also determined, giving a more accurate picture of the actual timeframe for the overall implementation process of solar and wind projects. The whole project implementation time was identified from the case studies carried out in the first phase of the study, through interviews with wind and solar park developers, and from a literature analysis on the implemented projects in the countries analysed.

1.1.2. Complexity

Another perspective for the RES project implementation process analysis is the complexity of the coordination process. Three different criteria have been chosen to define the complexity:

- **Number of contact points (contact institutions);**
- **Number of indirectly involved institutions;**
- **Many necessary documents to be prepared.**

One of the critical parameters is the number of authorities the project developer has to apply for permits or approval for the activities carried out under the project development process. The number of directly and indirectly involved contact points or institutions was identified in the previous two phases of the study. The RES Directive mentioned above recommends that for a smoother implementation of RES projects, there should be only one point of contact to obtain the necessary approvals or permits to facilitate the implementation of projects (European Parliament and the European Council, 2018; González et al., 2020).

The RES project implementation process sometimes indirectly involves other institutions whose opinion or consent is necessary to move forward. For example, in the case of wind turbines, this could be the military authorities, as the installation of wind turbines at certain heights could interfere with radar, or in the case of solar PV plants near an airport, the glare from the panels could pose a threat to air traffic safety.

The third criterion is the approximate number of documents required for project approval, as determined in the previous two stages of the study through an analysis of the legislation or found on the official websites of the authorities involved in the project approval process.

1.1.3. Information availability

Another essential aspect for a successful implementation of RES projects is information available on the number of approvals required from a legislative perspective. It includes two different criteria:

- **Availability of public information (available online);**
- **Accumulated knowledge on the project implementation.**

The authors of the research have qualitatively evaluated the availability of public information during the first two stages of this study and have rated it by using a 3-point scale:

3- information is easily accessible, can be found in one source about the whole coordination process and deadlines;

2- information is partially available, can be found in various sources that can be easily found;

1- information is challenging to find, and it is incomplete;

0- information can not be found, is not publicly available.

Authors also include accumulated knowledge of the project implementation process as a criterion because if there are more implemented RES projects, the developers have more precise un deep knowledge of the implementation process. Therefore, the projects can be implemented faster and with lower financial resources. The accumulated knowledge has been rated as the increase of RES installed capacities during the last three years.

1.1.4. Impact of public opinion

The local society can substantially impact the realisation of particular RES projects (Stephens & Robinson, 2021). Therefore, authors have identified local societies influence on the RES project permitting process during the first two stages of this study and evaluate the impact of public opinion on the project implementation by identifying three different criteria:

- **Number of public discussions to be carried out during the project implementation process;**
- **The opportunity of local society to influence the implementation of RES projects.**

The first identified criterion is the maximal number of public discussions about the RES project implementation approval, which was identified in the first two stages of this research through legislation analyses and publicly available information on official websites.

The second criterion is the possibility of local society to influence the implementation of RES projects. It is assessed through legislation and case study analyses by using a qualitative 3-point scale:

3- The public has sufficient opportunities to listen to the project implementers and influence the progress of the project, but there is no possibility to unreasonably suspend the implementation of the project;

2- The public has the opportunity to participate in public consultations and express their opinion, but there is no opportunity to unreasonably suspend the project;

1-The public has the opportunity to participate in public consultations and unreasonably stop the project;

0- Public consultations are not organised, although RES projects significantly impact the environment.

Authors consider that the possibility of local society to participate in the project implementation by obtaining in-depth information is valuable and necessary. However, unreasonable delays in project implementation caused by local inhabitants should be avoided. Therefore, the evaluation "0" is attributed in both cases- when there is an unreasonable negative impact on public opinion, and there is no participation of society.

1.1.5. Impact of municipality

The success and speed of the implementation of the RES project highly depend on the local authority's experience in coordinating this type of project and its attitude towards the technology, and therefore its ability to influence the process (Inderberg et al., 2019, 2020; Stephens & Robinson, 2021). The assessment thus includes criteria related to the possible influence of the municipality:

- **The opportunity of the municipality to influence the implementation of RES projects.**

The criterion has been determined by careful legislation and case study analyses obtained during the previous two phases of the study. The qualitative evaluation has been done by assigning points from 3-point scales. For the assessment of the municipality's opportunity to influence the implementation process, the following scale has been used:

3- The local government has vast opportunities to listen to the project implementers and influence the progress of the project, but there is no possibility to unreasonably terminate the project;

2- The municipality has the opportunity to cooperate with the project developer and express its opinion, but there is no possibility to unreasonably terminate the project;

1- The municipality can unilaterally suspend the progress of the project;

0- The municipality does not influence the progress of the project.

Similar to the evaluation of the public opinion, also for the municipalities, the authors consider that the possibility of local authorities to participate in the project implementation by obtaining in-depth information is crucial. However, unreasonable delays in project implementation caused by the municipality should be avoided.

1.2. Process comparison methodology

Evaluation of the indicators is not straightforward as different exceptions may occur during the assessment process. The analysis required to compare the countries included in the research involves a qualitative comparison, discussing the barriers in each country, and a quantitative comparison, assigning quantitative values to each criterion. The quantitative criteria analysis is carried out using a multicriteria decision-making approach to compare the different aspects of the RES implementation process. The result of the quantitative analysis is the country rank.

The obtained criteria values are evaluated using multicriteria decision analysis Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) and Analytic Hierarchy Process (AHP) methods. Multi-criteria decision analysis TOPSIS is a frequently used method to evaluate environmental strategies for sustainable development. The primary purpose of TOPSIS is to allow comparison and choice between several alternatives. The multicriteria decision analysis includes 10-15 different multicriteria analysis models (Zlaugotne et al., 2020). TOPSIS and AHP methods were chosen for this stage of the study because they are relatively more straightforward and better enable the comparison of qualitative and quantitative criteria. The methods to be applied are selected based on the type of result to be obtained. TOPSIS and AHP methods were used to make the results comparable and to identify the best possible alternative between the variables to be compared (Zlaugotne et al., 2020). More detailed information on the application and methodology of multicriteria decision analysis methods, including the TOPSIS method, can be found in the Riga Technical University Institute of Energy Systems and Environment publication "Multi-Criteria Decision Analysis Methods Comparison"(Zlaugotne et al., 2020), indexed in the SCOPUS and Web of Science databases.

The calculation was performed according to the steps and formulas listed below (Balioti et al., 2018; Krohling & Pacheco, 2015; Pachemska et al., 2014):

$$D = \begin{matrix} & C_1 & \dots & C_n \\ A_1 & x_{11} & \cdots & x_{1n} \\ \vdots & \vdots & \ddots & \vdots \\ A_m & x_{m1} & \cdots & x_{mn} \end{matrix} \quad (1)$$

where:

A1… Am - comparable alternatives;

C1… Cn - criteria according to which the comparison is performed;

Xij - performance/value of alternative i (where i is alternative 1 to m) according to criterion j (where j from 1 to n).

The normalisation of values is performed, and the normalised decision matrix is compiled.

$$D_{norm} = \begin{matrix} & C_1 & \dots & C_n \\ A_1 & r_{11} & \cdots & r_{1n} \\ \vdots & \vdots & \ddots & \vdots \\ A_m & r_{m1} & \cdots & r_{mn} \end{matrix} \quad (2)$$

The next step is to calculate the normalised rating using the formula:

$$r_{ij} = \frac{x_{ai}}{\sqrt{\sum_{a=1}^{n} x_{ai}^2}} \quad (3)$$

When the normalised evaluation of all alternatives according to the criteria mentioned above is obtained, it is necessary to determine the individual weight wi of each criterion. Weights are determined by meeting a condition - the sum of criterion weights equals 1. AHP method is used to determine the individual weight of each criterion. After completing the previous step, an AHP comparison matrix was developed to assess the significance of the criteria. A matrix of 3 pairs of evaluation criteria was created:

$$\begin{bmatrix} C_{11} & C_{12} & C_{13} & C_{14} \\ C_{21} & C_{22} & C_{23} & C_{24} \\ C_{31} & C_{32} & C_{33} & C_{34} \\ C_{41} & C_{42} & C_{43} & C_{34} \end{bmatrix} \quad (4)$$

When a pair element matrix is created, the sum of the columns of the pair element matrix is determined:

$$C_{ij} = \sum_{i=1}^{n} C_{ij} \quad (5)$$

The next step is to obtain a normalised matrix of pairs of elements, which can be done for each matrix by dividing the element by the total of the respective column:

$$X_{ij} = \frac{c_{ij}}{\sum_{i=1}^{n} c_{ij}} \begin{bmatrix} X_{11} & X_{12} & X_{13} & X_{14} \\ X_{21} & X_{22} & X_{23} & X_{24} \\ X_{31} & X_{32} & X_{33} & X_{34} \\ X_{41} & X_{42} & X_{43} & X_{34} \end{bmatrix} \quad (6)$$

The normalised values of the pair elements X_{ij} are then used to obtain a priority vector used in the TOPSIS analysis method as a criterion weight after calculation and consistency check. The priority vector is calculated according to the following formula:

$$W_{ij} = \frac{\sum_{j=1}^{n} x_{ij}}{n} \quad \begin{bmatrix} W_{i1} \\ W_{i2} \\ W_{i3} \\ W_{i4} \end{bmatrix} \quad (7)$$

The resulting priority vector or criterion weight for the TOPSIS method must be verified by checking the adequacy of the criteria assessment. Initially, the consistency vector is calculated by multiplying the resulting matrix by the priority vector obtained in the previous step:

$$Cv_{11} = \frac{1}{W_{11}}[C_{11}W_{11} + C_{12}W_{21} + C_{13}W_{31} + C_{14}W_{41}] \quad (8)$$

In the next step, use λ max to calculate the average value of the consistency vector:

$$\lambda_{max} = \frac{1}{n}\sum_{i=1}^{n} Cv_{ij} \quad (9)$$

The following two steps are to determine the consistency index CI and the consistency ratio CR:

$$CI = \frac{\lambda \max - n}{n-1} \quad (10)$$

$$CR = \frac{CI}{RI}, \; CR < 0{,}10 \quad (11)$$

In this case, RI is a random consistency index that is read from a random consistency index table, also called the Saaty scale. The first column of the table determines the number of rows in the matrix, and the second column is the random consistency index itself. If CR ≤0.1, then the level of consistency is considered acceptable, and the obtained criterion weights can be used for further calculations. Otherwise, consistency is considered low and expert judgment in the AHP comparison matrix should be reassessed.

The obtained weights for different criteria have been shown in Fig.1.3. The weights have been determined from the perspective of the project developer. Therefore, the highest values have been obtained for the number of contact points, public information available, and necessary documents.

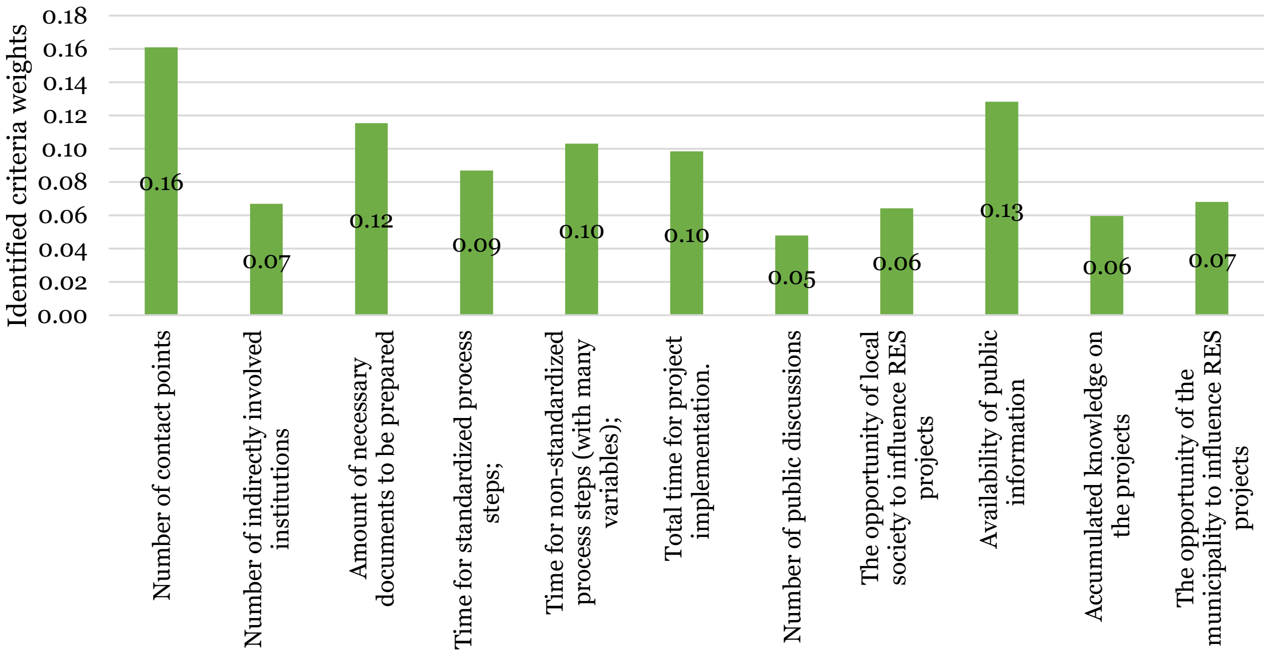

Fig. 1.3. Identified criteria weights

A matrix of weighted normalised decisions is constructed. Then, the criterion weights obtained and verified by the AHP method are further inserted into the TOPSIS method and used for further calculations. In the next step, the criteria weight values w_i obtained by the AHP method are multiplied by the normalised values ria to obtain the normalised weighted value v_{ai}, as shown in equation 12:

$$v_{ai} = w_i * r_{ia} \tag{12}$$

When the normalised weighted decision matrix is constructed, the ideal positive solution $\boldsymbol{d_a^+}$ and the ideal negative solution $\boldsymbol{d_a^-}$ are calculated. Initially, the distance to the ideal solution (MAX) and the distance to the anti-ideal solution (MIN) are determined. Distances are determined by formulas:

$$=\text{MAX}(v_{a1}:v_{a3}) \tag{13}$$

$$=\text{MIN}(v_{a1}:v_{a3}) \tag{14}$$

The next step after determining the distance to the ideal and anti-ideal solution is to determine the ideal positive and ideal negative solution according to the formulas:

$$\boldsymbol{d_a^+} = \sqrt{\sum_{j=1}^{n}(\boldsymbol{v_i^+} - \boldsymbol{v_{ai}})^2} \tag{15}$$

$$\boldsymbol{d_a^-} = \sqrt{\sum_{j=1}^{n}(\boldsymbol{v_i^-} - \boldsymbol{v_{ai}})^2} \tag{16}$$

The relative proximity of the alternative to the ideal solution is calculated as shown in formula No.17:

$$\boldsymbol{C_a} = \frac{\boldsymbol{d_a^-}}{\boldsymbol{d_a^+} + \boldsymbol{d_a^-}} \tag{17}$$

The result is equal to values that show the proximity of the alternative to the ideal positive solution and the distance from the ideal negative solution. A re-evaluation of criterion is performed, assigning equal values to all alternatives to determine the impact of the weights of the criteria set by the AHP on the evaluation of criterion.

2. RESULTS

2.1. Obtained values of analysed criteria

2.1.1. Timeline for the project implementation

The duration of implementing a standardisable process for different RES projects compared among the analysed countries has been shown in Table 2.1. The most extended process timeline to set up microgenerators has been identified in Norway and Estonia due to the long building permit process. The most prolonged timeline for large and average solar plants is in Lithuania and Estonia, but in Lithuania and Sweden for wind farms. It has been estimated that the most extended duration is in Lithuania but shortest in Finland for offshore wind parks.

Table 2.1. Average duration (days) of standardisable processes for different types of RES projects

Country	Microgeneration	Average/large solar plants	Average/large wind farms	Offshore wind farms
Latvia	30	91	61	78
Lithuania	0	109	99	118
Estonia	60	185	185	180
Finland	14	58	51	58
Norway	0	83	124	60
Sweden	70	70	130	140

Based on the information gathered in the first two phases of this study, the estimated timeline for non-standardisable processes is based on the legislative framework and several assumptions, as the precise duration for such processes as environmental impact assessment or changes in spatial planning documents is project-specific and within the same country can differ not only by days but by months. Nevertheless, because of the above, the authors have estimated the duration of each RES project.

Table 2.2. Average duration (days) of non-standardised processes for different types of RES projects

Country	Microgeneration	Average/large solar plants	Average/large wind farms	Offshore wind farms
Latvia	30	343	1676	2819
Lithuania	48	519	1878	3100
Estonia	30	720	1817	2555
Finland	30	720	1268	2363
Norway	90	638	822	2639
Sweden	90	430	1247	2738

The real-time it takes for the RES technology project development depends on different aspects, and therefore the implementation differs for each project. As mentioned above, the factors affecting the implementation of a project are manifold and may be related to many factors - preparation of the necessary documentation, any additional assessment by the authorities concerned, environmental impact assessment, the construction process, etc. Table 2.3. shows the information obtained from the case studies analysed and the required project development time for solar PV parks and onshore or offshore wind farms. In the Baltic states - Latvia, Estonia and Lithuania - only implemented onshore wind park projects were reviewed, as offshore wind parks are still in the planning/implementation phase. The study shows that on average, offshore wind projects take 6.5 years to complete (*Key Project Dates for Lithuanian Tender 1 - 2023 - Lithuania | 4C Offshore*, n.d.; *Offshore Wind Farms in Latvia | 4C Offshore*, n.d.; *Offshore Wind Farms in Lithuania | 4C Offshore*, n.d.; *Vi Hittar Inte Sidan…*, n.d.; Pimenta De Miranda et al., 2010), compared to 5 years for onshore wind (*Eesti Energia Windaparks*, 2011; *Fortum to Build Its First Finnish Large Scale Wind Park in Närpes | Fortum*, n.d.; *Paldiski Onshore Wind Farm Officially Opened in Estonia | GE News*, n.d.; *Raggovidda Wind Farm - Multiconsult*, n.d.; *Sāksies Vēja Parka "Tārgale" Būvniecība* , n.d.; *The Sjisjka Wind Farm | Skanska - Global Corporate Website*, n.d.; *The Windfarm - UAB Windfarm*, n.d.; *Windfarm Design - UAB Windfarm*, n.d.). Solar PV development projects are mostly completed within 1-2 years (*Atria Expands Finland's Largest Solar Park to Almost Double - New Investment in Nurmo to Start in July - Atria Oyj*, n.d.; *Estonia's Largest Solar Power Plant Started Operating in Pärnu — Eesti Gaas*, n.d.; *Latvenergo Starts Construction of Solar Panel Parks in Estonia and Lithuania / Article / LSM.Lv - World Today News*, n.d.; *Nya Solevi Solar Farm One Year on – the Story so Far - Smart City Sweden*, n.d.; *Saules Kolektoru Sistēmas Ar Siltumenerģijas Akumulācijas Tvertni Un Biomasas Katlu Mājas Ar 3MW, Latvija, Salaspils*, n.d.).

Table 2.3. Summary of analysed projects and the implementation timeline

Country	Project name, capacity	Timeline
Onshore wind projects		
Norway	Raggovidda Wind Farm (45MW)	2010 - 2014
Sweden	Sjisjka wind farm (78MW)	2011-2012
Finland	Kalax wind park in Närpes(Fortum) (90MW)	2017-2021
Estonia	Paldiski Onshore Wind Farm (22,5MW)	2008-2013
Latvia	Wind park Tārgale (58,8MW)	2011-2022
Latvia	Wind farm Latflora (50 MW)	2008-2024
Lithuania	UAB Wind Farm in Akmenė one (75MW)	2013-2021

Offshore wind projects		
Norway	Havsul I (350MW)	2004-2009
Sweden	Lillgrund (110MW)	1997-2007
Finland	Kemi Ajos (25MW)	2006-2009
Estonia	Saare Wind Energy (1,400 MW)	2015-2023
Latvia	*No realized projects*	
Lithuania	*No realised projects*	
Solar power projects		
Country	**Project**	**Timeline**
Sweden	Nya Solevi	2018-2019
Finland	Solar park in Nurmo	2021-2022
Estonia	Tallin Utilitas solar power plants (10-50 kW)	2019-2020
Estonia	solar plant in Pärnu - Eesti Gaas and Paikre OÜ	2018-2019
Latvia	"Jurmalas siltums" solar power plant	2018-2019
Latvia	Microgeneration of residential house	July – November, 2018
Lithuania	Elektrum Lietuva park in Klaipeda District(1,5MW)	2020-2021

2.1.2. Complexity

The number of contact points or directly involved institutions for different RES projects has been summarised in Figure 2.1. Summary of listed directly and indirectly involved contact points can be found in the Appendix.

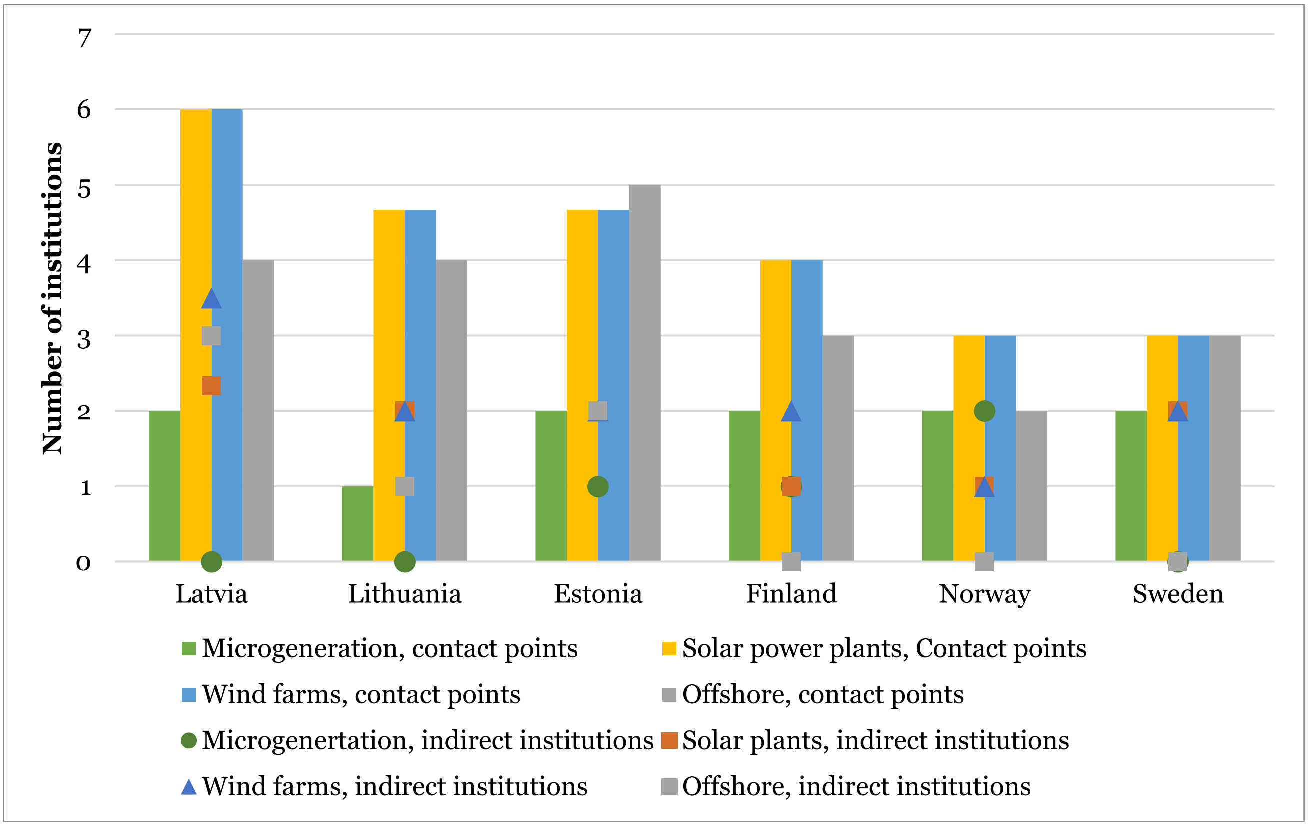

Fig.2.1. Number of contact points and indirectly involved institutions for different RES projects

Fig.2.1 shows the number of contact points (local and national authorities) involved in the project's implementation process and obtaining all necessary permits or approval. As it can be seen, the number of contact points for the installation of micro-generators is limited to one or two authorities. The first authority is usually the local municipality or the municipal building authority, which assesses and, if necessary, issues the building permit, which provides a legal basis to install a micro-generator. In all cases except Sweden, the second point of contact is the distribution system operator, which coordinates the connection to the electricity grid. Finally, in the Swedish case, an electrical installer at an electrical installation company should be contacted for the connection establishment.

The number of contact points during the implementation process of solar PV and wind park projects overlap in all the countries assessed. The most contact points are in the Baltic states, particularly Latvia. Although the number of possible contact points is the same in Sweden and Norway, Norway is the only country in the study that has conceptually implemented the coordination process through a single contact point. The Norwegian Water Resources and Energy Directorate (the NVE) is the central point of contact, which advises the developer on the other authorisation process (The Norwegian Water Resources and Energy Directorate, 2021a). In addition, the local municipality needs to be contacted for smaller size power plant installations in some instances.

The number of contact points for offshore wind farms is roughly similar to that for onshore wind farms.

It was impossible to identify the exact number of institutions indirectly involved during the study, as they are not always listed in the legislation or the officially available guidelines. The authorities directly involved in the process, when assessing whether to grant a permit, themselves contact the authorities indirectly involved, who then give their views on the environmental and technical aspects likely to have a significant impact. The identified number of indirectly involved authorities is roughly the same in all the countries included in the study.

The number of documents required for implementing RES technologies was obtained from the analysis of legislation or found on official web pages of authorities involved in the project approval process. It was identified during the first two stages of this study. The data is summarised in Figure 2.2. The analysis shows that developers need to submit a more significant number of documents for introducing renewable energy technologies in the Baltic states than developers in the Nordic countries. This difference could be because, in the Baltic states, the legislation defines certain documents that must be prepared and submitted to obtain specific permits. In contrast, there is no such indication in the legislation in the Nordic countries. The documents to be submitted are probably specified through communication with the authorities concerned.

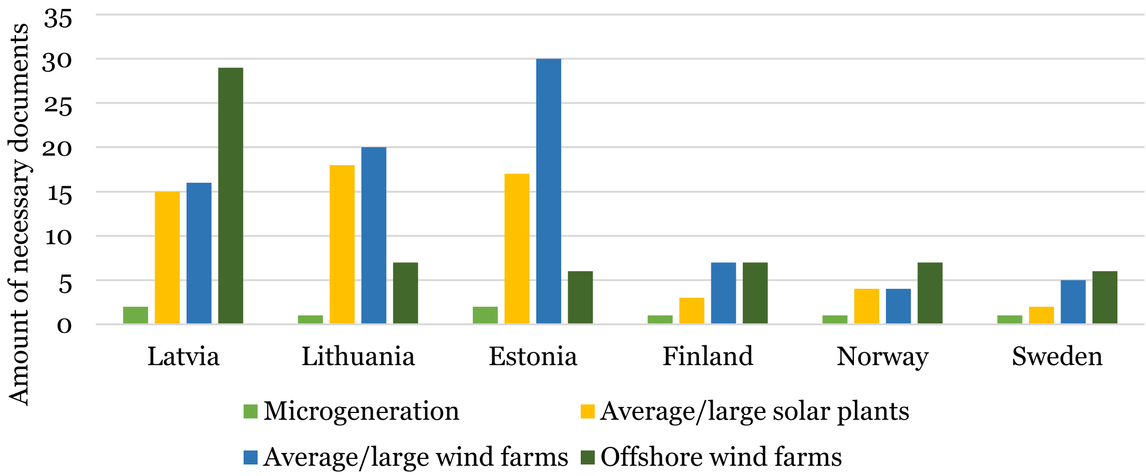

Fig. 2.2. Number of necessary documents for RES technologies

Most often mentioned documents are applications for issuance of the necessary permits - building permits; permits for energy production; permit for selling electricity; application and technical documentation for connection to the network and environmental impact assessment programs and reports. Installation of microgeneration equipment requires only a few documents that vary depending on the installation's technology, capacity, and location. For medium and large-scale solar power plants, wind farms, and offshore wind farms, the number of documents required is quite similar, mainly depending on the constraints for the chosen site, as there are areas where additional permits are needed.

2.1.3. Information availability

The information available for the RES project implementation process has been evaluated using a scale described in Section 1.1.3. The accessibility ratings were obtained by analysing the information available on each country's official websites and, where necessary, reviewing the legislation—the analysis aimed to find comprehensive and explanatory official information in one place. Preference was given to more user-friendly sources of information for the potential RES technology developer (explanatory information dedicated to the technology, infographics, process diagrams), and only in cases where no official information was found, a description of the administrative process was sought in legislation and regulations. Accordingly, to find official and transparent information on the steps of the administrative process and the authorities to go to if necessary for the installation of microgenerators, solar PV panels, wind turbines and offshore wind farms. The highest score of 3 points was given if the information was easily accessible, could be found in one source about the whole coordination process and deadlines. A correspondingly lower score was given if information had to be sought about each step of the administrative process from different sources and was incomplete or if confusion remained after the information had been gathered.

The results have been summarised in Table 2.7. As can be seen from the evaluation, the most comprehensive information about necessary permits and implementation processes can be found in Norway. It might be because the project development process for solar and wind power plants is managed by one contact point – the NVE, which summarised all the necessary information in one source (The Norwegian Water Resources and Energy Directorate, 2021c, 2021b). Furthermore, the main stages of project implementation have been described and published on the NVE's website, where additional information and references to the relevant legislation can be found as well (The Norwegian Water Resources and Energy Directorate, 2021b, 2021c). Although Sweden does not have a single contact point system and the process of approval of the development of RES power plant projects is left to the municipalities, comprehensive information on the implementation of solar and wind projects can be found on The Swedish Energy Agency's website (The Swedish Energy Agency, 2020). Sweden has also developed a handy tool for using the Planning and Building Act "PBL Knowledge Bank" (PBL knowledge bank, 2020), which explains in great detail the application and interpretation of the Planning and Building Act depending on the activity to be carried out concerning territorial planning and construction.

Table 2.4. Summary of information availability evaluation

Country	Microgeneration	Solar plants	Wind farms	Offshore wind farms
Latvia	2	2	1	2
Lithuania	3	2	2	2
Estonia	1	1	1	2
Finland	1	2	1	2
Norway	1	3	3	3
Sweden	2	3	3	2

The accumulated knowledge indicator is based on the number of implemented RES project capacity from 2015 to 2019 and the country's population. If more RES projects are implemented, more knowledge and experience are gained, which is helpful for future project development. Therefore, the indicator is evaluated as the increase of RES installed capacities of the last four years.

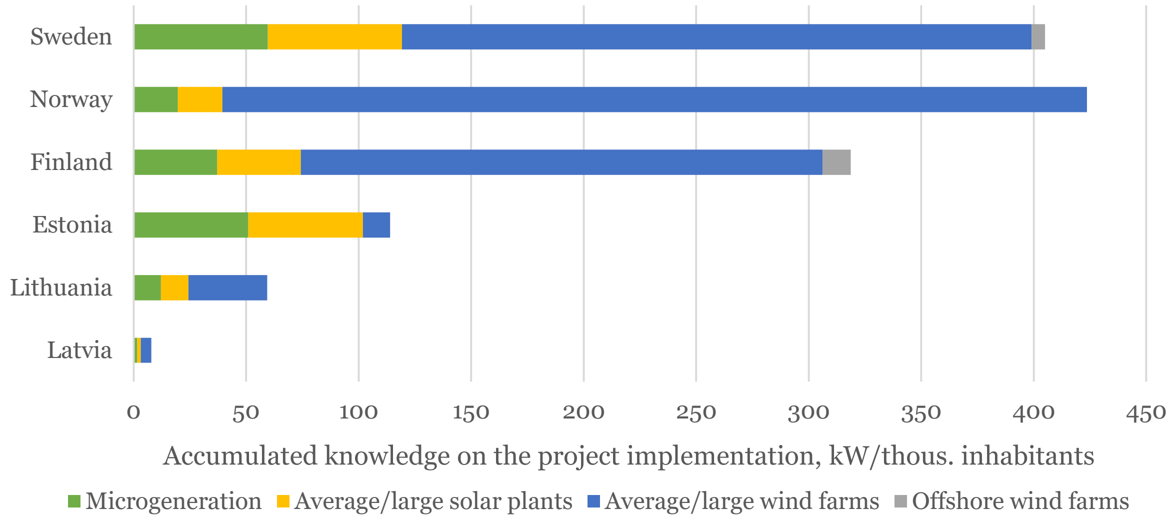

Fig.2.3. Countries total accumulated knowledge ratio on RES technologies

Total accumulated knowledge on RES technologies is shown in Figure 2.3. Norway and Sweden have the best knowledge and experience with renewable energy technologies. Estonia has experienced the most significant increase in installed capacity among the Baltic countries in recent years, but this can still be considered low compared to the Nordic countries.

2.1.4. Impact of public opinion

The impact of public opinion has been evaluated through two criteria – the number of public discussions regarding RES project implementation and the possibility of society to impact the implementation of the RES project. For more specific information on these criteria, see the first two phases of this study. As none of the analysed countries has public discussions on the installation of microgeneration equipment and small-scale projects because of their insignificant size and possible low impact on the environment and safety, these criteria have been excluded from further analysis.

The summary of obtained criteria values can be seen in Fig.2.4. The lowest society impact for solar projects has been identified for Latvia, where there is no necessity to organise public discussions regarding solar plant installation.

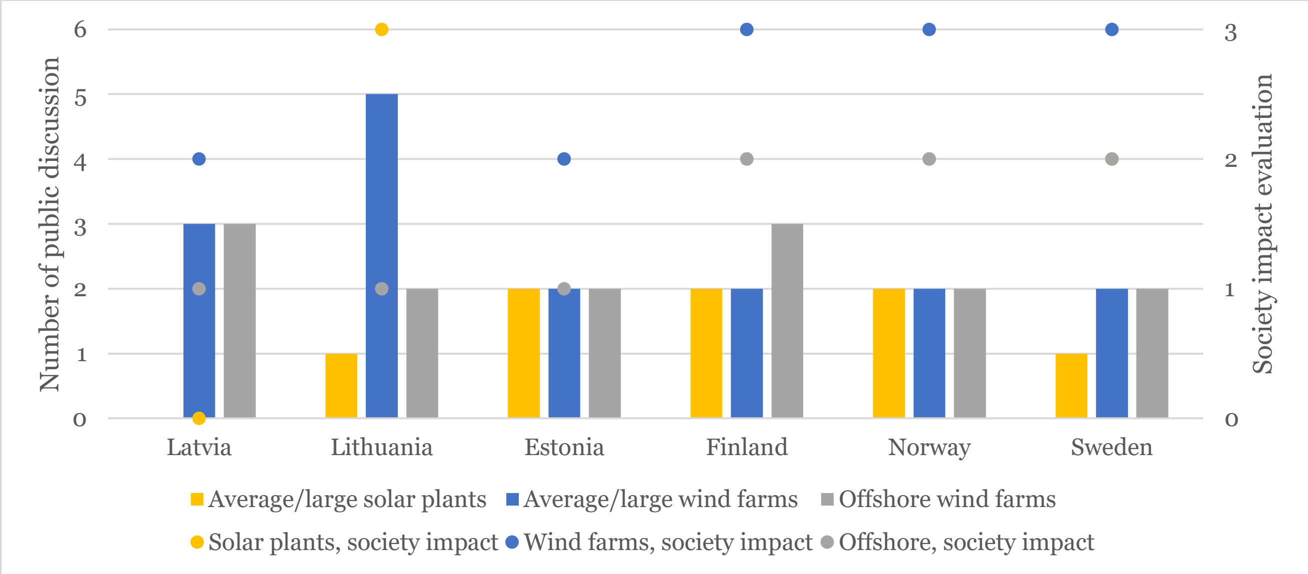

Fig.2.4. Overview on society impact evaluation

The highest score for social impact has been identified for wind farms in Finland, Norway, and Sweden, where the local inhabitants are well informed. Still, they cannot reject the project without significant reasons.

2.1.5. Impact of municipality

The evaluation results for the impact of municipalities has been assessed during the first two stages of this study and summarised in Table 2.8. In addition, the evaluation scale has been described in Section 1.1.5.

Table 2.5. Summary of municipality impact evaluation

Municipality impact	Average/large solar plants	Average/large wind farms	Offshore wind farms
Latvia	3	1	0
Lithuania	3	1	0
Estonia	1	1	0
Finland	3	2	2
Norway	3	3	2
Sweden	1	1	2

As can be seen, the highest score is attributed to solar power plant installation in Latvia, Lithuania, Finland, and Norway, where the local government has vast opportunities to listen to the project implementers and influence the project's progress. However, there is no possibility to suspend the project's progress unreasonably. The local municipalities are not directly involved in the offshore project implementation in Baltic states.

2.2. Multicriteria analyses results

The obtained criteria values have been normalised and weighted according to the methodology described in Section 1.2. The normalised values have been presented in Appendix 2. The obtained results have been presented separately for different RES project types.

Fig.2.5. shows the multicriteria decision analysis results for microgeneration projects. Lithuania scored the highest among all countries because the Law of the Republic of Lithuania on Energy from Renewable Sources clearly describes the regulatory framework for microgeneration installations - capacity limits, simplified installation process in terms of territorial and building permits. Finland has the second-highest score, while Sweden is not far behind, Norway and Estonia follow closely. According to the multicriteria decision analysis, Latvia scores the lowest in implementing microgeneration projects.

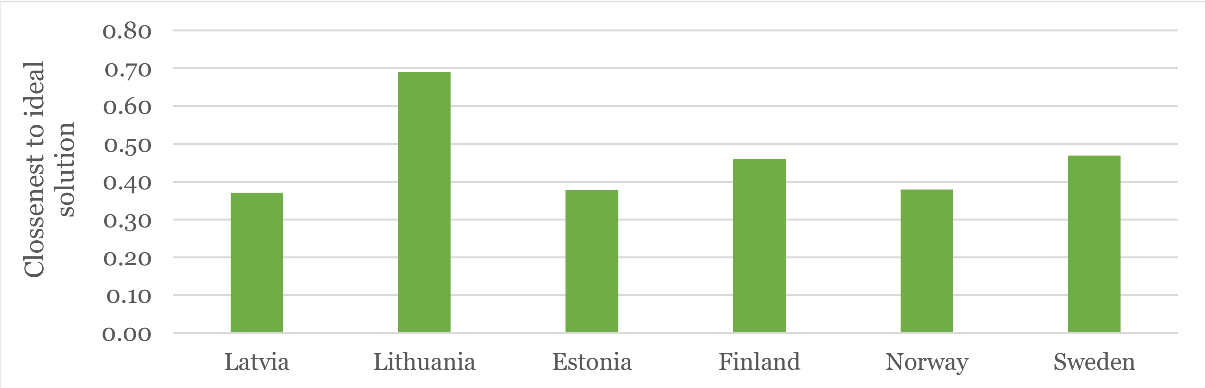

Fig.2.5. Multicriteria analysis results for microgeneration projects

Fig.2.6. shows the multicriteria decision analysis results for implementing the average and large-scale solar power plant. Nordic countries have obtained the highest rank - Sweden with the highest score, followed by Norway and Finland due to the lower number of contact points for the necessary permit receiving and the increased information availability. Baltic states have received the lowest results, with Lithuania right behind Finland, Latvia, and Estonia. Estonia is ranked lowest since solar PV projects may be subject to an EIA and a need for changes to spatial plans compared to other countries.

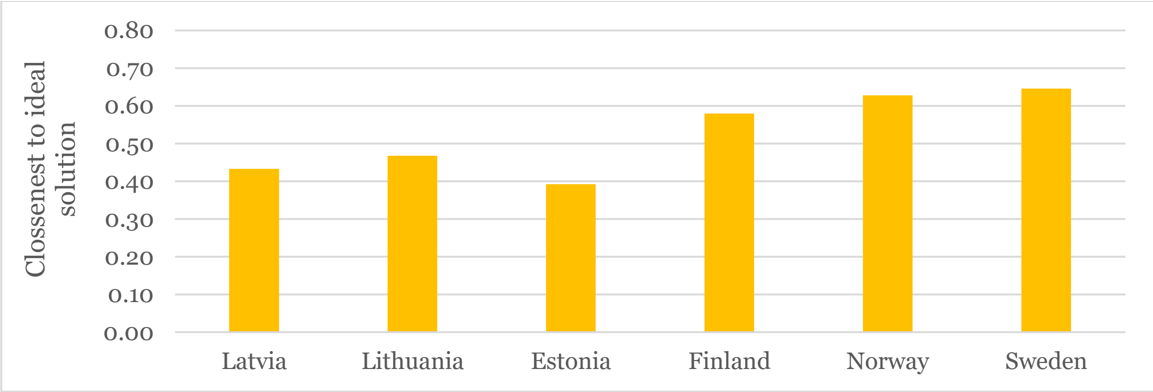

Fig.2.6. Multicriteria analyses result for average and large-scale solar power plants

Fig.2.7. shows the results for the implementation process of onshore wind farm projects. It can be seen that analysed countries have received similar evaluation scores. However, the evaluation results show slightly higher scores for Nordic countries due to fewer involved institutions in the implementation process and shorter project implementation timelines. The implementation of wind farm projects in Norway is also proceeding more smoothly due to the combined permitting processes.

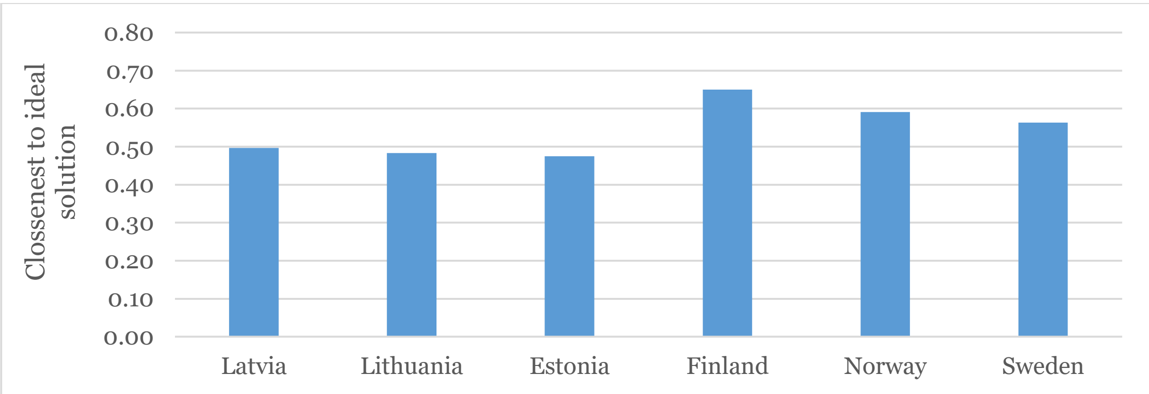

Fig.2.7. Multicriteria analyses result for average and large-scale wind farms

Fig.2.8. shows the multicriteria analysis results for the implementation of offshore wind farm projects. It can be seen that Finland has a slightly higher result due to the lower number of involved institutions and higher accumulated knowledge on offshore wind project implementation. However, it has been taken into account that the analysis of the implementation process of offshore wind park projects in the Baltic states is theoretical because all Baltic states still have shortcomings in their legislative framework or have not fully adopted it, and no offshore projects have been implemented yet.

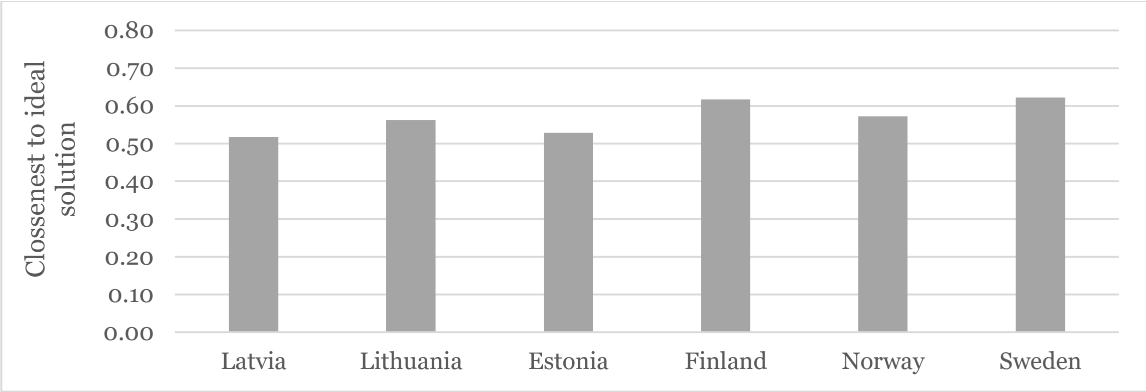

Fig.2.8. Multicriteria analysis results for offshore wind farms

The results obtained from multicriteria decision analysis indicate more significant differences among the analysed countries regarding implementing the microgeneration and larger-scale solar power plant. The administrative procedure for wind farms shows similar results. However, the study's analysis did not include the criteria describing the division of power plants into micro-generation, medium-sized, and large-sized plants based solely on installed capacities. While in the Baltic states, a micro-generator is classified as a plant with a capacity between 11.1 and 30 kW. In the Nordic countries, higher capacities for micro-generation are defined - Sweden with 43.5 kW, Norway with 100 kW, and Finland with 2 MVA. The same applies to large-scale solar and wind farms, where larger capacities are being installed in the Nordic countries than in the Baltic countries, so it should be noted that the approval process could be more complex in the Nordic countries. For example, an EIA for a wind farm in Finland is required starting from 45 MW, while in the Baltic states, e.g., Latvia, an EIA is applicable starting from 5 MW.

CONCLUSIONS

The study compares the implementation process of the RES power plant project in Baltic and Nordic countries by considering 11 different criteria and applying multicriteria decision-making methods. The comparison has been made by considering the project implementation timeline, complexity, information availability, and the impact of local society and municipalities. In addition, the number of contact points, public information available, and the number of documents necessary for the project's approval has been identified as the primary evaluation criteria.

The administrative procedure for implementing microgeneration equipment, solar PV power plants, and wind farm projects consists of several variables that cannot be assessed entirely in time units. Standardisable processes directly related to issuing specific permits are carried out within standard timeframes of 30-70 days, which is not considered a significant constraint on the overall project implementation time. On the other hand, non-standardisable processes such as EIA, changes to the spatial planning documents, and grid connection are highly project-specific and time-consuming.

Therefore, the non-standardisable part of the project implementation process, which is mainly the responsibility of the municipalities, could be a key factor for faster project realisation. A conclusion drawn from the results of this comparison shows that, even though administrative processes tend to take longer in the Nordic countries (up to 10 weeks in Sweden), project implementation is happening much smoother. It could be closely linked to the accumulated knowledge, which seemingly plays a significant role not only for the power plant developers but also for the municipal staff doing the assessment: the more experience and transparency in project assessment, the clearer the requirements for developers and the smoother the process of coordination.

The volume of documents to be submitted and the number of institutions involved cannot be objectively assessed from a solely legislative point of view. In the authors' view, an accurate and objective assessment of this indicator would be possible through practical participation in a RES project development or interviews carried out with the representatives of the directly involved authorities.

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APPENDIX

Appendix 1. Involved institutions

Table 1. Summary of involved institutions for microgeneration project implementation

Country	Contact points	Indirectly involved institutions
Latvia	County Construction Board	
	DSO	
Lithuania	DSO	
Estonia	Local municipality	Local building authority
	DSO	
Finland	Local municipality	One licence point
	DSO	
Norway	Local municipality	
	DSO	
Sweden	Local municipality	The Planning and Building Agency
	Electrical installation company	

Table 2. Summary of involved institutions for average and large-scale solar power plant project implementation

Country	Contact points	Indirectly involved institutions
Latvia	Ministry of Economics	Civil Aviation Agency
	Local building authority	Ministry of Defence
	The State Inspection for Heritage Protection	
	Public Utilities Regulatory Commission	
	DSO or TSO	
	Local municipality	
Lithuania	The National Energy Regulatory Council	The Lithuanian National Commission for Cultural Heritage
	DSO or TSO	Lithuanian Armed Forces
	Local municipality	
	Local building authority	
Estonia	Local municipality	Geologists
	DSO or TSO	The Ministry of Defence
	Environmental Board	The Register of Economic Activities
	The Competition Authority	
	JSC Elering	
Finland	Energy Market Authority	The Centre for Economic Development, Transport and the Environment
	The Energy Agency	The regional environment centre, the regional council and the local authority
	The Ministry of the Environment	
	Local building supervision authority	
Norway	The Norwegian Water Resources and Energy Directorate (NVE)	The Ministry of Petroleum and Energy
	Local municipality	
	Statnett	
	DSO	
Sweden	Local municipality or region	The National Board of Housing, Building and Planning
	Municipality's building committee	Energy and climate advisor
	Electrical installation company which is registered with the Swedish Electrical Safety Agency	DSO

Table 3. Summary of involved institutions for average and large-scale wind farm implementation

Country	Contact points	Indirectly involved institutions
Latvia	Ministry of Economics	Ministry of Defence
	Local building authority	Civil Aviation Agency
	DSO or TSO	State Environmental Service regional environmental board
	Public Utilities Regulatory Commission	
	Local municipality	
	The State Inspection for Heritage Protection	
	Environment State Bureau	
	State Environmental Service	
Lithuania	State Energy Regulatory Council	Commander of the Lithuanian Armed Forces
	DSO or TSO	Minister of Health of the Republic of Lithuania
	Local municipality	
Estonia	Local municipality	Eight different Ministries
	JSC Elering	Geological surveys
	Environmental Board	
	The Competition Authority	
Finland	The Energy Agency	The Centre for Economic Development, Transport and the Environment
	The Ministry of the Environment	The regional environment centre, the regional council and the local authority
	Local building supervision authority	
	DSO or TSO	
Norway	The Norwegian Water Resources and Energy Directorate (NVE)	Pollution authority
Sweden	Local municipality or region	The municipal board
	County Administrative Board	City Council
	The Swedish Environmental Protection Agency	Municipality's environmental and health protection board
	Municipality's building committee	DSO
	Electrical installation company	

Table 4. Summary of involved institutions for offshore wind farm implementation

Country	Contact points	Indirectly involved institutions
Latvia	Ministry of Economics	Maritime Administration of Latvia
	Environment State Bureau	Cabinet of Ministers
	TSO	State Environmental Service
	Public Utilities Regulatory Commission	
Lithuania	Government of Lithuania	Ministry of Environment
	TSO	
	The State Territorial Planning and Construction Inspectorate	
	The Environmental Protection Agency	
Estonia	Consumer Protection and Technical Supervision Board	The Building Permit Procedural Body
	TSO	The Consumer Protection and Technical Surveillance Authority
	Technical Surveillance Authority	
	Ministry of the Environment	
	The Ministry of Economic Affairs and Communications	
Finland	The Ministry of the Environment	
	The Ministry of Agriculture and Forestry	
	Local municipality	
Norway	The Ministry of Petroleum and Energy	
	The Norwegian Water Resources and Energy Directorate (NVE)	
Sweden	Local municipality or region	
	The Land and Environmental Court	
	County administrative board	
	TSO	

Appendix 2. Normalised values used in the multicriteria assessment

Table 1. Normalised criteria values for microgeneration RES projects

Criteria	*Number of contact points*	*Number of indirectly involved institutions*	*Amount of necessary documents*	*Time for none standardised process steps*	*Time for standardised process steps;*	*Availability of public information*	*Accumulated knowledge*
Latvia	1.0	0.0	1.0	0.0	0.4	0.5	1.0
Lithuania	0.0	0.0	0.0	0.3	0.0	0.0	0.8
Estonia	1.0	0.5	1.0	0.0	0.9	1.0	0.1
Finland	1.0	0.5	0.0	0.0	0.2	1.0	0.4
Norway	1.0	1.0	0.0	1.0	0.0	1.0	0.7
Sweden	1.0	0.0	0.0	1.0	1.0	0.5	0.0

Table 2. Normalised criteria values for solar plants

Criteria long	*Number of contact points*	*Number of indirectly involved institutions*	*Amount of necessary documents*	*Time for none standardised process steps*	*Time for standardised process steps;*	*Total time for project implementation.*	*Number of public discussions*	*Society impact*	*Availability of public information*	*Accumulated knowledge*	*Municipality impact*
Latvia	1.0	1.0	0.8	0.0	0.3	0.3	0.0	1.0	0.5	1.0	0.0
Lithuania	0.4	0.8	1.0	0.5	0.4	1.0	0.5	0.0	0.5	0.8	0.0
Estonia	0.4	0.8	0.9	1.0	1.0	0.0	1.0	0.3	1.0	0.1	1.0
Finland	0.3	0.0	0.1	1.0	0.0	1.0	1.0	0.3	0.5	0.4	0.0
Norway	0.0	0.0	0.1	0.8	0.2	1.0	1.0	0.3	0.0	0.7	0.0
Sweden	0.0	0.8	0.0	0.2	0.1	1.0	0.5	0.3	0.0	0.0	1.0

Table 3. Normalised criteria values for wind farms

Criteria long	*Number of contact points*	*Number of indirectly involved institutions*	*Amount of necessary documents*	*Time for none standardised process steps*	*Time for standardised process steps;*	*Total time for project implementation.*	*Number of public discussions*	*Society impact*	*Availability of public information*	*Accumulated knowledge*	*Municipality impact*
Latvia	1.0	1.0	0.5	0.8	0.1	0.7	0.3	0.0	0.0	0.0	0.0
Lithuania	0.6	0.4	0.6	1.0	0.4	0.7	1.0	0.0	0.5	0.1	0.0
Estonia	0.6	0.4	1.0	0.9	1.0	1.0	0.0	0.0	0.0	0.0	0.0
Finland	0.3	0.4	0.1	0.4	0.0	0.7	0.0	1.0	0.0	0.6	0.5
Norway	0.0	0.0	0.0	0.0	0.5	0.0	0.0	1.0	1.0	1.0	1.0
Sweden	0.0	0.4	0.0	0.4	0.6	0.7	0.0	1.0	1.0	0.7	0.0

Table 4. Normalised criteria values for offshore wind farms

Criteria long	***Number of contact points***	***Number of indirectly involved institutions***	***Amount of necessary documents***	***Time for none standardised process steps***	***Time for standardised process steps;***	***Number of public discussions***	***Society impact***	***Availability of public information***	***Accumulated knowledge***	***Municipality impact***
Latvia	0.7	1.0	1.0	0.6	0.2	1.0	0.0	0.0	0.0	0.0
Lithuania	0.7	0.3	0.5	1.0	0.5	0.0	0.0	0.0	0.0	0.0
Estonia	1.0	0.7	0.0	0.3	1.0	0.0	0.0	0.0	0.0	0.0
Finland	0.3	0.0	0.5	0.0	0.0	1.0	1.0	0.0	1.0	1.0
Norway	0.0	0.0	0.5	0.4	0.0	0.0	1.0	1.0	0.0	1.0
Sweden	0.3	0.0	0.0	0.5	0.7	0.0	1.0	0.0	0.5	1.0