A Comparison of the European Regulatory Framework for the deployment of Offshore Renewable Energy Projects

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Abstract—[1] **The REPower EU Plan has set a minimum of total renewable energy generation capacity of 1,236 GW by 2030. Achieving this target, and emission reductions by 2050, will require the extensive deployment of offshore energy facilities, especially offshore wind (OW) and wave energy converters (WECs). However, an incomplete and sometimes unfavourable regulatory framework still jeopardises the feasibility of both prototypes and large-scale installations. There are, for example, significant differences between the permitting procedures in different Member States and regions. Moreover, following the transposition of the Directive 2014/89/EU "establishing a framework for maritime spatial planning", important differences pertain to the way environmental and heritage protection is dealt with. An overview of the offshore permitting schemes for offshore wind in ten European counties (Germany, Denmark, Scotland, Sweden, France, Spain, Portugal, Italy, Belgium, and Ireland) is provided, demonstrating a mismatch between the current members' complex regulations and the future offshore wind targets. Using customised key performance indicators, we describe and assess the extent to which the regulatory frameworks are conducive to installing industrial devices in achieving the country's 2030 target. Finally, we propose actions to facilitate the installation of OW while ensuring both environmental protection and industry development in the countries under investigation.**

Keywords—**Regulatory framework, MCDM analysis, Offshore Wind, Wave Energy Converter**

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I. INTRODUCTION

Climate change and its human and environmental consequences are the most important future challenges for Europe and the world. The European Green Deal [1] outlines a path for the EU to become a modern and sustainable economy. In this context, massive investments in renewable energy sources are necessary. Offshore energy is crucial because of its abundance and lower environmental impact. Indeed, there are offshore wind and marine energy resources in the 5 European sea basins. The marine energy market is characterised by a vast panorama of devices [2], such as Wave Energy Converters (WEC) [3][4], Tidal technologies [5], Ocean Thermal Energy Converter (OTEC) [6] and Salinity Gradient [7].

The EU Offshore Renewable Energy Strategy (COM (2020)741) [8] has set two main targets: 60 GW of offshore wind capacity and 1 GW of ocean energy by 2030; and 300 GW and 40 GW, respectively, by 2050. In addition, the European Commission redefined REPowerEU targets through the Fit for 55 packages [9] to achieve a 55% reduction in greenhouse gases (GHG) by 2030. European countries are pursuing different strategies to achieve these goals and have set offshore wind energy development targets. Fig. 1 gives an overview of the installed capacity until 2022 and the targets until 2030. According to the Key Trends and Statistics 2022 from Ocean Energy Europe [10], the current capacity of wave energy in the water across Europe is 400 kW; the tidal stream is 13 MW.

Although there are several test installations of marine energy converters across Europe, current development is mainly at the demonstration or pre-industrial level. According to the European Commission's [11], the most widespread projects have a Technology Readiness Level (TRL) of 5/6. Consequently, most of the regulations of the offshore wind industry are sometimes applicable to marine energy converters.

Although the current offshore wind market has gained momentum in recent years, there has been a significant improvement in reducing permitting bottlenecks [12]. Indeed, constructing new power plants and repowering wind farms require several steps before they are completed. The reason for this is the high complexity of regulations related to spatial planning requirements. The procedures are lengthy because too many authorities are involved, and the licensing regulations must be adequately staffed. Nevertheless, regional cooperations such as the North Seas Energy Cooperation (NSEC) [13] and the Baltic Energy Market Interconnection Plan (BEMIP) [14] aim to accelerate and facilitate the development of European offshore wind. Furthermore, only four Member States (Portugal, France, Denmark and Spain) have improved their permitting system in their national energy and climate plans to achieve the European target.

Due to the complexity of the permitting procedures, it is a challenge to create a comprehensive framework for the existing legal and regulatory processes in the European offshore sector. The complexity of the permitting processes affects several aspects that influence offshore renewable energy development.

Therefore, many authors and international bodies have addressed this issue in order to solve the related problem of financial barriers to development, which is mainly related to the achievement of European decarbonisation targets. A comprehensive overview of the current picture of the timelines for issuing offshore wind licensing allows us to determine the economic attractiveness and competitiveness of the sector for foreign and domestic investors. Prassler and Schaechtele [15] investigated the financial attractiveness of various European countries for the offshore wind market using a comparative analysis of various KPIs (Key Performance Indicators). The study found a strong correlation between the complexity of the permitting procedures and the competitiveness of the countries studied.

The European Commission has also produced some studies on the regulation of offshore wind energy. In particular, Serrano Gonzàles and Lacal Arantegui [16] have proposed an analysis of the regulatory barriers to offshore wind energy development, examining in detail the regulatory frameworks of Belgium, Denmark, Germany, the Netherlands and the United Kingdom.

Fig. 1. Installed and Planned Capacity in Europe

WindEurope, the main European association of the wind energy industry, published in 2021 the "Overview of National permitting rules and good practices" [17]. The document presents the current European regulatory mosaic in offshore wind permitting. It looks at the permitting procedures of 28 EU and non-EU countries, highlights the standard requirements and provides information on the total lead time for each country. The report highlights a severe mismatch between countries regarding transparency of the requirements and planning.

Other researchers propose a broader perspective and provide a comparative analysis of the regulatory frameworks in Europe, the US, Japan and New Zealand. The study conducted by Schumacher [18] focused on the differences in Environmental Impact Assessment (EIA) procedures in the countries studied for Large-Scale RES initiatives, which are a crucial step in the approval processes for RES projects and illustrates how streamlining the EIA process via "one-stop shops" promotes overall implementation time.

IRENA [19] proposed a study on renewable energy in Southeast Europe, which examined the permitting procedures for renewable energy. Barriers to the permitting of renewable energy power plants and infrastructure were analysed. Four main bottlenecks for renewable energy projects were identified: market, technical and regulatory barriers, economic and financial barriers, administrative bottlenecks, and lack of awareness, capacity and professional skills. In particular, administrative and regulatory barriers can lead to significantly high costs for renewable energy supply.

In addition, Ramos et al. [20] proposed to assess the regulatory framework for marine renewables in the Atlantic European countries. The researchers identified corrective measures for the further development of the sector. They conclude that streamlining permitting procedures and timelines, ideally by introducing a "one-stop-shop" approach, is crucial to attracting new developers and investors to the marine industry.

Several studies stated that offshore wind development would benefit from a homogenous regulatory framework across countries and specific decision-making tools and processes [12][20]. Moreover, many researchers include the licencing procedures for new RES installations or the policy framework as an evaluation criterion in their Multicriteria Decision Making (MCDM) analysis to assess the readiness of countries to achieve climate targets. For example, Büyükozkan et al. [21] proposed an Analytical Hierarchical Process (AHP) to assess the effectiveness of energy policies in achieving the SDGs, based mainly on a collection of expert opinions. Instead, Abdel-Basset et al. [22] instead addressed spatial planning for offshore wind by integrating the policy framework as a risk issue and conducting an MCDM based on a mixture of AHP and Preference Ranking Organisation Method for Enrichment Evaluation (PROMETHEE). However, as far as the authors are aware, no studies have been conducted to assess the suitability of national legal frameworks for the development of offshore renewable energy projects.

TABLE I
OFFSHORE WIND CAPACITY VALUE UPDATE IN 2022

Country	Installed Capacity [GW]	Target Capacity [GW]
Germany	8.10	30.00
Netherlands	2.80	21.50
Denmark	2.31	5.00[a]
France	0.50	6.80
Belgium	2.26	4.00[b]
Ireland	0.03	3.50[b]
Italy	0.03	3.50
Norway	0.07	3.10
Scotland	1.00	11.0
(UK)	(13.9)	(50.0)
Sweden	0.19	0.70[c]
Spain	0.00	3.00
Portugal	0.025	10.00[d]

[a] Update in 2021.
[b] Update in 2019.
[c] No NSEC target yet, just the Baltic Sea contribution.
[d] Maximum value of auctions.

In this paper, we present an analysis of the current legal frameworks and authorisation procedures for offshore wind projects in European countries. In order to compare the results using an appropriate aggregate indicator, we also apply an MCDM to rank countries in terms of their readiness for offshore wind development.

A. Scope and structure of the work

This paper primarily addresses the complex framework of the authorisation procedures concerning installing offshore wind turbines in European countries.

Despite the ambitious targets set by the European Commission with the Fitfor55 package for offshore wind capacity, the current discrepancy between Member States' regulations does not allow for a homogeneous development and a common investment strategy. Table I shows the current picture of the already deployed and the planned capacity.

According to the EMODnet [23] and WindEurope [24] databases, most planned capacity still needs to be authorised. Fig. 2 shows a GIS elaboration of European countries with a detailed status of offshore wind project status. It can be observed that the number of planned offshore wind projects overshadows the overall initiatives. However, the offshore wind projects already in operation are much fewer than those planned due to a complex and stringent permitting process.

This work faces this miscellaneous panorama by collecting the available data on the lead time, required phases and authorities involved in granting construction permits and licences for offshore wind and proposes tailor-made KPIs to present the current picture of offshore wind development.

These KPIs were processed using an MCDM analysis based on the Criteria Importance Trough Intercriteria Correlation (CRITIC) method proposed by Diakulaki et al [25] to assess the correlation between the parameters and propose a ranking of the current regulatory frameworks of each country studied.

The paper provides a multi-criteria analysis proposing appropriate weightings for assessing the effectiveness of policies.

II. Materials and Methods

This chapter is composed of three sections: A. Data collection, which consists of defining the input data related to the permitting schemes of the different European countries; B. Key Performance Indicators, which are established assessment parameters to measure the regulatory framework of EU countries; C. Multicriteria Decision- CRITIC method representing the MCDM method adopted by the study.

A. Data collection

The first step for this case study is to collect data to define the permitting systems for offshore wind in the different European countries. The main parameters that will be analysed are the different stages of the permitting framework, the national and regional authorities involved and the time required for the whole permitting process. Ten European countries are studied.

1) Germany, Denmark and Scotland in a "one-stop-shop" mechanism

Firstly, Germany, Denmark and Scotland are characterised by a streamlined process using a "one-stop-shop" mechanism. The central "one-stop-shop" government authority manages the necessary permits, licences and consultations for the development of offshore wind projects. This approach also includes public hearing of other government agencies to express concerns and objections. In Denmark, the entire process is handled by the Danish Energy Agency (DEA) [26], which

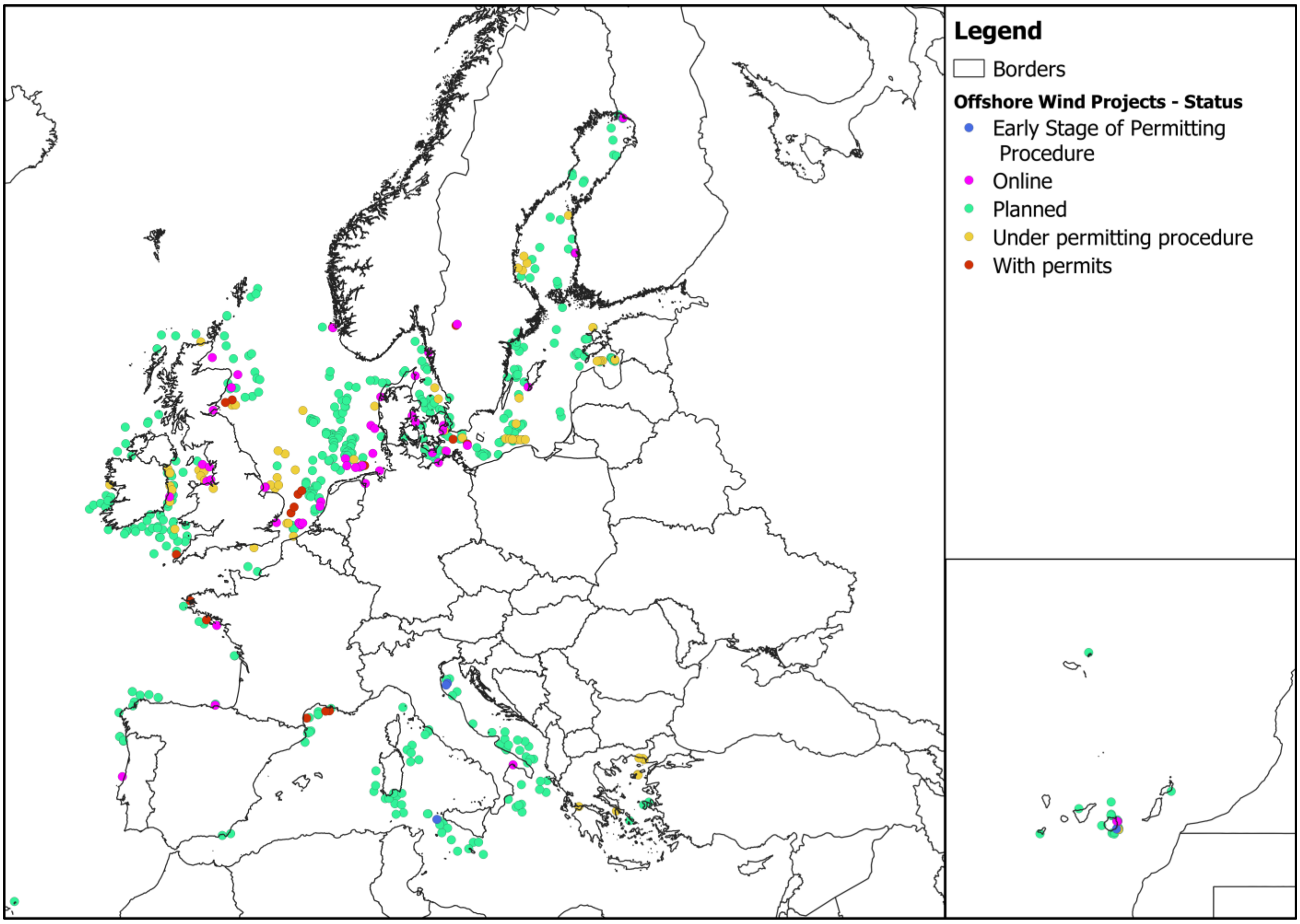

Fig. 2. Installed and Planned Capacity of European Countries

issues licences for preliminary investigation, construction, electricity production and electricity production authorisation. The German licencing permitting process includes a marine spatial planning survey of the exclusive economic zone (EEZ), a site investigation and the submission of the application for planning permission, which is coordinated by the Federal Maritime and Hydrographic Agency (BSH) [27]. Finally, in Scotland, the authority responsible is Marine Scotland [28], which manages the pre-application process consisting of mock-ups of proposed development and preparation of the Environmental Impact Assessment (EIA), as well as the determination and subsequent consent stages.

2) Sweden

The Swedish permitting system for offshore wind turbines involves three steps overseen by different authorities. First, the developer's feasibility study is processed by the country's administrative authority, then the application is administered by the Mark and Miljödomstolen (MMD) [29]; this is followed by the application and the EIA, which are coordinated by the country's administrative authority and an environmental trial delegation respectively; finally, appeals can still be made to the environmental courts.

3) France

The French authorisation framework is complex and characterised by seven passages: pre-application; submission of the application for environmental authorisation; examination phase, handled by both the Prefecture and Environmental authority, i.e. the Regional Mission of the Environmental Authority (MRAe) [30], and the Ministry of Civil Aviation and Air Force; public consultation; approval or rejection by the departmental prefect; application for the grid connection permit; and finally, the commissioning.

4) Ireland

The Irish framework also consists of seven sections: pre-application meetings; pre-application community engagement, which is not mandatory but strongly recommended; submission and validation of the planning application, which is carried out by local authorities; consultation step managed by public authorities; request for further information; approval or refusal by local planning authorities; and finally commissioning. For developments considered 'strategic' to the state, a Strategic Infrastructure Development (SID) [31] process may also be put in place, managed directly by the authority.

5) Belgium

The Belgian authorisation system consists of four phases: domain concession, released by the Federal Minister of Energy; the marine protection authorisation, managed by the Scientific Service Management Unit of the North Sea Mathematical Models (MUMM) [32] and also submitted to the Public Inquiry, and the final decision, released by the Federal Minister of Marine Environment; then come the submarine cable authorisations, dealing with the Federal Minister of Energy, and finally the grid connection step.

6) Spain

The authorisation of offshore wind farms in Spain is characterised by several necessary steps with the approval of the competent authorities [20]. First, the pre-application process is done for the zone reservation permit, which is awarded through a tendering process by the State Secretariat of State for Energy, open to promoters interested in a specific area. The best application, taking into account the technical, economic and environmental characteristics, receives approval. The following permits are required for the construction and exploitation of offshore wind power plants: administrative authorisation to validate or amend the execution projects proposed by the developer; project execution authorisation, which is granted after the public consultation process; and, finally, exploitation authorisation, which allows grid connection and commercial exploitation. In particular, the occupation of the marine space for the concession of the public domain is managed by the Directorate of Sustainability of the Coast and Sea. Electricity generation, composed of administrative authorisation, project execution authorisation and operating authorisation, is supervised by the General Directorate of Energy Policy and Mines. The Environmental Impact Assessment (EIA), which can be a normal EIA or a simplified EIA depending on the size of the offshore wind farm, is managed by the General Directorate of Quality and Environmental Assessment of the Environment. The permit for the use of public ports and the maritime safety license are issued by the Port Management Authority and the Directorate General of Merchant Marine, respectively.

7) Portugal

The Portuguese permitting system for offshore wind includes various necessary permits and involved authorities. An Allocation Plan is only required for projects where the area of interest is designated in the Siting Plan for something other than offshore wind. Both public and private initiatives can propose allocation plans. Approval requires statutory consultation, an EIA and public discussion. Subsequently, developers must apply for a permit for private use of marine space, which is administered by the General Directorate for Natural Resources, Safety and Maritime Services. For electricity generation, an operating licence is required, which is the responsibility of the General Directorate of Energy and Geology [33]. In addition, the grid operator must apply for a grid connection licence (EDP - Energias de Portugal).

8) Italy

The Italian authorisation procedure is divided into three main parts due to the lack of Maritime Spatial Planning; the first step concerns the domain concession; the second is the Unique Authorization (AU), which includes the Environmental Impact Evaluation (VIA), mainly consisting of the Scoping phase and the Environmental Impact Assessment, and the last is the grid connection application, which has to be forwarded to the National TSO [34].

Different administrative authorities are involved in each phase. In general, the concession for the area must be issued by the Minister of Infrastructure and Transport (MIT) and the AU; meanwhile, the release of the VIA decree is the responsibility of the Minister of Environment (MASE). The VIA procedure includes a public consultation period, where the EIA is published on the MASE online portal.

Italian legislation foresees an additional environmental procedure if the project affects a Natura 2000 Network site, the so-called Environmental Incidence Assessment (VInCA) administratively simultaneous with the VIA procedure. Various national and regional authorities issue binding and non-binding opinions during the AU and VIA procedures. After receiving the AU and VIA decrees, MIT releases the domain concession and the construction permit.

B. Key Performance Indicators

Five key performance indicators have been derived from research conducted by Wind Europe [17] and Jack [35] and included in the analysis to develop an assessment of the different permitting frameworks, focusing on highlighting institutional barriers and administrative bottlenecks. The following KPIs are considered:

1) **n° of phases [-]** - Number of steps of the authorisation process. It permits identifying the possible influence on the grade of the complexity of the overall permitting process.
2) **n° of authorities [-]** - Number of authorities involved in the authorisation process. It represents the number of national and regional institutions handling and evaluating various offshore wind projects.
3) **Administrative time [months] -** Time necessary to obtain permits such as domain concession and environmental impact; no EIA preparation and grid connection permit time are considered.
4) **Total lead time [months]** - It is the overall time from the first project submission to obtain the different permits up to the final grid access concession; no construction time and no legal challenges are considered to assess the official time in which each country can conclude the overall process, exceptional cases are not considered.
5) **Achievement rate [-] –** It is the ratio between each country's installed offshore wind capacity (year 2022) and its 2030 target.

KPIs are quantified directly from the permitting scheme processes outlined earlier. They aim to quantify how much bureaucratic obstacles, non-transparent administrative procedures, and strict laws influence offshore renewable energy projects' final approval and realisation. It is obvious that the higher the number of phases, the more complex the process. In addition, a higher number of authorities can lead to a longer administrative time, directly affecting the Total lead time.

Finally, the percentage completion rate is a direct consequence of each country's specific authorisation framework, and it enables the identification of a country's best administrative process in relation to its goals.

Furthermore, this analysis introduces a decision parameter to select countries with the necessary information to conduct the study: data completeness is assessed as a ratio value from 0 (no information is published) to 1 (all necessary information is available). Only European countries with a data completeness ratio

TABLE II
KEY PERFORMANCE INDICATORS

Country	n° of phases [-]	n° of authorities [-]	Administrative time [months]	Total lead time [months]	Achievement rate [%]	Completeness of data [-]
Germany	3	1	24	36	0.27	1.00
Denmark	4	1	Nd.	Nd.	0.46	0.60
France	7	3	24	36	0.07	1.00
Belgium	4	4	13.2	14.7	0.57	1.00
Ireland	7	2	Nd.	Nd.	0.01	0.60
Italy	3	3	Nd.	Nd.	0.01	0.60
Scotland	3	1	19.5	29.3	0.09	1.00
Sweden	3	3	24	36	0.27	1.00
Spain	5	6	Nd.	Nd.	0.00	0.60
Portugal	4	4	24	36	0.0025	1.00

of 1 are considered, i.e. Belgium, Germany, Scotland, France, Sweden and Portugal. Table II summarises the four KPIs and the indicators of data completeness: The less information published by the different EU countries, the lower the data completeness, leading to the exclusion of Spain, Italy, Denmark and Ireland from the analysis.

C. *Multicriteria Decision-Making Analysis – CRITIC Method*

The proposed multicriteria analysis is based on the CRITIC Method [25] to provide the weight of each KPI in each national authorisation process. In his general form, it is possible to define a multicriteria problem as a set A of n alternatives evaluated through m evaluation criteria f_j, generally:

$$Max\ \{f_1(a), f_2(a), \dots, f_m(a)\ /\ a\ \in A\ \} \tag{1}$$

For each f_j criterion, the method defines a function x_j able to map the f_j in the interval [0,1] according to the distance from an ideal solution. In reason of that, the method defines an ideal solution equal to 1 and the worst solution equal to 0. The intermediate solutions have been evaluated using the following:

$$x_{aj} = \frac{f_j(a) - f_{j^*}}{f_j^* - f_{j^*}} \tag{2}$$

Which f_j^* represents the best solution for the specific evaluation criterion, and f_{j^*} the worst one. Equation (2) allows us to build a matrix of relative scores where the x_j represents the score of *all* n alternatives concerning the *j-th* criterion.

$$x_j = (x_j(1), x_j(2), \dots, x_j(n)) \tag{3}$$

According to Mukhametzyanov [36] and Diakulaki [25], the information in MCDM problems relates to both contrast and conflict of decision criteria.

The parameter C_j obtained by aggregation of the standard deviation σ_j from (3), measures the conflict created by the *j-th criterion* concerning the other, and the correlation term r_{jk} , represents the amount of information conveyed by the *j-th criterion*.

$$C_j = \sigma_j * \sum_{k=1}^{m} (1 - r_{jk}) \tag{4}$$

A higher value of C_j corresponds a higher quantity of information carried and therefore its importance in the whole MCDM process. Finally, the objective weights are obtained by:

$$W_j = \frac{C_j}{\sum_{k=1}^{m} C_k} \tag{5}$$

The objective weights calculated through (5) enable to define of a scoring equation, i.e.:

$$D_i = \sum_{j=1}^{m} w_j * x_{ij} \tag{6}$$

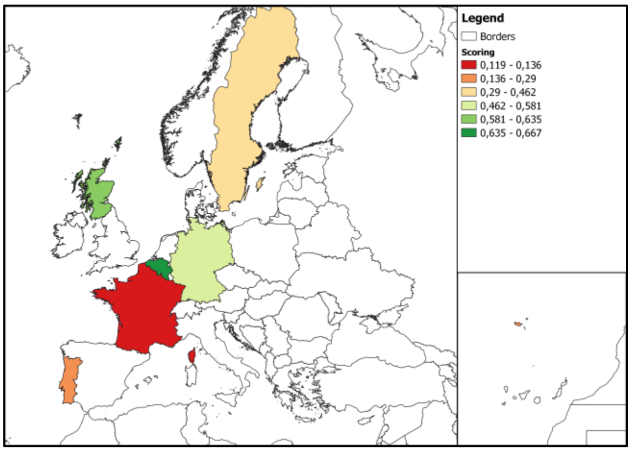

Fig. 3. Country Ranking

III. RESULTS AND DISCUSSION

The method exposed previously has been applied to the KPIs reported in Table II, describing the importance of each evaluation criterion within the investigation.

The evaluation criteria derived from the KPIs analysis are summarised in Table III.

TABLE III
EVALUATION CRITERIA

Evaluation Criteria	xj
N° phases	x_a
N° of authorities	x_b
Administrative time	x_c
Total lead time	x_d
Achievement rate	x_e

Equation 2 shows that the ideal solution and worst one are case-dependent. According to the literature review, a lower value of n° of phases, n° of authorities, and lead times are preferable. At the same, a higher value of Achievement rate represents the best solution.

According to (3), the relative scores of each evaluation criterion are reported in Table IV.

TABLE IV
RELATIVE SCORE MATRIX

Country	x_a	x_b	x_c	x_d	x_e
Belgium	0.75	0	1	1	1
Germany	1	1	0	0	0.47556

Scotland	1	1	0.41667	0.3169	0.1517
France	0	0.33	0	0	0.12627
Sweden	1	0.33	0	0	0.4781
Portugal	0.75	0	0	0	0
σ_j	0.353	0.415	0.374	0.368	0.332

The n° of Authorities is characterised by a higher standard deviation value, which means that this specific KPI reports a higher level of conflict, demonstrating the heterogeneousness of the administrative phase across the investigated countries.

The correlation matrix R, reported in Table V, which elements are the r_{jk}, has been built implementing a linear correlation between criteria.

TABLE V
CORRELATION MATRIX

1	0.378	0.131	0.101	0.260
0.378	1	-0.230	-0.293	-0.193
0.131	-0.230	1	0.995	0.721
0.101	-0.293	0.995	1	0.763
0.260	-0.193	0.721	0.763	1

The higher correlation values are recorded for the Administrative time and the Total lead time, which is reasonable as they represent the core of the authorisation phase. Moreover, Administrative time has an impact on the Achievement rate; a higher issuing time clearly distorts the installed capacity.

Table VI shows the C_j evaluated according to (4); the n° of authorities seems to be the KPI which transmits more information to the problem.

TABLE VI
AMOUNT OF INFORMATION TRANSMITTED

C_a	C_b	C_c	C_d	C_e
0.845	1.307	0.786	0.807	0.813

Equation 5 allows the evaluation of the objective weights of the MCDM problem.

TABLE VII
OBJECTIVES WEIGHTS

W_a	W_b	W_c	W_d	W_e
0.185	0.287	0.172	0.177	0.178

Table VII highlights the objective weights calculated within the MCDM analysis and the number of authorities involved in issuing offshore wind licenses. Accordingly, the data collected biases the MCDM problem contributing to the final ranking more than the others.

According to (6), the final rank calculated is reported in Table VIII.

TABLE VIII
FINAL RANKING

Country	Score
Belgium	0.667
Scotland	0.629
Germany	0.557
Sweden	0.366
Portugal	0.139
France	0.119

As reported in Table VIII and shown in Fig. 3, Belgium has obtained the highest score derived by each weight combination.

IV. CONCLUSION

The analysis shows the great heterogeneity of authorisation procedures across Europe, highlighting the need for a "one-stop-shop" system as envisaged by the European Commission.

Indeed, the n° of administrations recorded the highest value as an objective weight, despite a "one-stop-shop" mechanism that can ensure a single administrative point of contact to avoid bottlenecks. The MCDM analysis shows that the effectiveness of the policy also depends on the reduction of administrative and total issuance time, which is related to the n° of phases, which represent the milestone in achieving the 2030 targets. For this reason, Belgium scored the highest.

Scotland and Germany, which adopt the "one-stop-shop" mechanism, are ranked second and third. This result is due to the limited number of authorities involved and the number of phases. In addition, Scotland has a higher final score compared to Germany due to the lower administrative and lead time. It is also interesting to note that although Germany has a higher achievement rate, this does not strongly impact the overall ranking value. Therefore, a faster regulatory framework can quickly achieve the 2030 capacity target, regardless of the actual installed capacity.

As soon as the number of involved authorities and phases increases, the final ranking value drops sharply. France and Portugal belong to this case. Although their administrative and lead times align with those of the other European countries studied, the excessive number of phases and authorities disadvantages these two countries. Moreover, France has a lower score, although the success rate is higher than in Portugal due to the high number of phases. In conclusion, to promote OW's capacity building, a shortening of approval periods and a "one-stop shop" system are strongly recommended.

Furthermore, only six countries were included in the study because of a lack of data published by national authorities. An improvement in transparency seems necessary to broaden the number of countries and refine the results.

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