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Environmental assessment reform under the offshore wind power special act: changes and challenges

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Abstract

The Special Act on the Promotion of Offshore Wind Power Supply and Industry Development (Act No. 20845; hereinafter "Offshore Wind Special Act"), promulgated on March 25, 2025, and enforced on March 26, 2026, represents a landmark legislative shift in South Korea's offshore wind development paradigm—transitioning from a private sector-led, site-by-site approach to a government-led, planned-site system. The Act introduces a one-stop permitting framework consolidating 42 permits across 28 statutes, with the Offshore Wind Power Committee under the Prime Minister centralizing inter-ministerial decision-making, thereby reducing projected development timelines from approximately ten years to five to six years. A defining feature of the Act is Article 26, which integrates the environmental impact assessment (EIA) under the Environmental Impact Assessment Act and the Marine Environment Impact Assessment (MEIS) under the Marine Environment Management Act into a unified "Environmental Assessment" regime. Complementarily, Article 32(4) of the Enforcement Decree permits baseline survey data collected at the preliminary zone stage to substitute for portions of the detailed assessment at the development zone stage, theoretically compressing review periods from over 30 months to approximately 15 months. This paper conducts a comparative legal analysis of the former dual-track system and the new integrated framework, critically examining three contentious provisions: the narrowing of avifaunal survey scope (Annex to Article 4 of the Enforcement Ordinance), exemption from reassessment for design modifications below 30% (Article 34 of the Enforcement Decree), and exclusion of environmental specialists from public-private consultative councils (Article 15 of the Enforcement Decree). Drawing on Denmark's and the United Kingdom's Strategic Environmental Assessment (SEA) frameworks and international empirical literature, the paper proposes institutional reforms to reconcile South Korea's 14.3 GW offshore wind deployment target by 2030 with the imperative of marine ecosystem conservation.

Keywords: planned-site system, Strategic Environmental Assessment (SEA), energy justice, environmental assessment integration, offshore wind permitting

Introduction

As international responses to the climate crisis intensify, the South Korean government has designated offshore wind power as a core strategic industry and set a national goal of carbon neutrality by 2050. Under the 11th Basic Plan for Long-term Electricity Supply and Demand

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No AI tools were used in this article.

(Ministry of Trade, Industry and Energy, 2025), the target share of renewable energy in electricity generation is 21.7% by 2030 and 29.2% by 2038, with an offshore wind deployment target of 14.3 GW by 2030. Yet as of late 2024, commercially operational offshore wind capacity stood at only approximately 290–360 MW, representing a target achievement rate of 2%–3% (Orrick, 2026; Power Magazine, 2026). South Korea's offshore wind deployment shortfall has been attributed to a compound of regulatory bottlenecks, permitting delays, and stakeholder conflicts (Windpower Monthly, 2025). In particular, the dual-track environmental review system—the Ministry of Environment's EIA and the Ministry of Oceans and Fisheries's MEIS—has been identified as a structural bottleneck capable of consuming more than 30 months in environmental review alone for large-scale projects (EEAS, 2024; Korea Times, 2024).

To address these structural constraints, the Offshore Wind Special Act—passed by bipartisan consensus on February 27, 2025, promulgated on March 25, 2025, and enforced from March 26, 2026—aims to shorten project timelines and enhance regulatory predictability through a government-led planned-site system and an integrated Environmental Assessment regime. However, several provisions introduced in the subordinate legislation to accelerate approvals have raised concerns about substantive weakening of environmental protection standards. International scholarship consistently warns that, in the absence of rigorous environmental review, offshore wind projects can generate serious ecological and social harms, including bird collisions (Bradbury et al., 2014; Dierschke et al., 2016), underwater noise (Green et al., 2022; Madsen et al., 2006), electromagnetic fields (EMFs) from submarine cables (Dannheim et al., 2020; Hutchison et al., 2020), and fisheries and community conflicts (Kim et al., 2020; Park et al., 2022, 2024).

Against this background, this paper pursues four research objectives: (1) to analyze the structural limitations of the former dual-track environmental assessment system in light of empirical evidence; (2) to examine the specific content of the integrated Environmental Assessment framework introduced by the Offshore Wind Special Act and its subordinate legislation at the level of individual legal provisions; (3) to evaluate the position of the South Korean framework relative to the Strategic Environmental Assessment (SEA) systems of leading offshore wind nations such as Denmark and the United Kingdom; and (4) to propose concrete policy reforms to achieve a genuine balance between energy transition and marine ecosystem conservation.

Structure and limitations of the former environmental assessment system

1. Legal structure of the dual-track system

Prior to the enforcement of the Offshore Wind Special Act, environmental screening for South Korean offshore wind projects operated under a bifurcated legal structure applying two independent statutory regimes in parallel according to project capacity. Projects with a generating capacity of 100 MW or more were required to complete both an environmental impact assessment (EIA) under the Environmental Impact Assessment Act (under the jurisdiction of

the Ministry of Environment) and a Marine Environment Impact Assessment (MEIS) under the Marine Environment Management Act (under the jurisdiction of the Ministry of Oceans and Fisheries). Projects between 50 MW and 100 MW were subject only to the Large-Scale MEIS (MEIS-MA), while projects below 50 MW fell under the Simplified MEIS (MEIS-GE or MEIS-MI).

The two assessment regimes were structurally distinct in their procedures. Under the EIA, developers submitted an assessment report to the Ministry of Environment, which then issued consultation opinions after coordinating with relevant agencies—progressing through draft public review (45 days), submission of the final report, and consultation (30 days, extendable). Under the MEIS, a separate report was submitted to the Marine Environment Impact Assessment Center under the Ministry of Oceans and Fisheries, with the Minister of Oceans and Fisheries issuing independent consultation opinions. For projects of 100 MW or above, the two procedures had to be conducted effectively in sequence, resulting in environmental review alone typically requiring 22 to 30 months or more. Offshore wind projects in South Korea proceed through five stages—feasibility analysis, electricity business license, individual permits, development authorization, and construction and commissioning—and the dual-track environmental review served as the most time-consuming structural bottleneck in this process (EEAS, 2024; Korea Times, 2024).

A further critical problem of the dual-track system was the "jurisdictional gap" between the two regimes. The EIA applied a standard set of items centered on terrestrial concerns—air quality, water quality, soil, noise and vibration, ecosystems, and landscapes—directly to offshore projects, while the MEIS was designed around marine environmental standards (water quality, sediment, marine organisms). As a result, environmental impacts specific to offshore wind power—including auditory injury to marine mammals from underwater pile-driving noise, disruption of benthic organisms by EMF from submarine cables, and fragmentation of migratory bird flyways by large turbines—were not mandated as assessment items under either regime, creating substantial blind spots in environmental review (Lee et al., 2015; Oh et al., 2021). The dual requirement to prepare separate reports for the same sea area imposed additional administrative burdens on developers, while the absence of an inter-ministerial coordination body meant that conflicting content between the two reports had to be resolved by developers independently.

2. Substantive deficiencies in assessment content: review of domestic empirical evidence

A systematic review of marine environmental impact assessment reports for nine offshore wind projects conducted in South Korea between 2012 and 2019 documented the substantive deficiencies of the former assessment framework (Oh et al., 2021). The review found that in the majority of reports: (1) reliable information on fishery resource stocks was not presented; (2) systematic assessment of the impacts of underwater noise, vibration, and EMF on marine ecosystems was exceedingly rare; and (3) procedures for anticipating and mitigating

conflicts arising from the spatial overlap of project areas with fishing grounds were almost entirely absent. Serious conflicts with local fishing communities were reported across all nine projects reviewed, a direct consequence of projects proceeding without adequate prior environmental and social impact assessment. Notably, not one of the reports reviewed contained a quantitative assessment of operational noise impacts on marine mammals, EMF effects from submarine cables, or collision risks to individual bird populations—because these offshore wind-specific items had not been incorporated into the statutory assessment checklist, revealing a fundamental systemic deficiency in the assessment framework itself.

It was also diagnosed that the absence of clearly defined assessment types for marine energy development projects meant that no systematic framework existed for mandating the offshore wind-specific environmental impact items—including bird collisions, underwater noise, sediment disturbance, and EMF effects—as priority assessment concerns (Lee et al., 2015). That study further noted that assessment review for marine energy development was conducted using the same item framework applied to general reclamation and dredging projects, without reflecting the sector-specific characteristics of offshore wind, with the result that the broad-scale ecological effects arising from the increased size and clustering of offshore wind turbines were not being systematically evaluated. A review of international monitoring cases similarly found that domestic environmental impact surveys were concentrated on pre-construction baseline surveys, with operational-phase monitoring extremely inadequate, and that integrated ecological monitoring systems encompassing bird collisions, marine mammal dynamics, and benthic ecosystem changes were urgently needed (Maeng et al., 2013). The former dual-track system thus simultaneously harbored a triple structural deficiency: inter-ministerial fragmentation at the legal-structural level, omission of offshore wind-specific impacts at the assessment-item level, and absence of post-commissioning monitoring over the project lifecycle.

3. Key deficiencies by assessment category: evidence from international literature

1) Underwater noise

Impulsive noise generated during pile driving constitutes the most severe underwater acoustic threat in offshore wind construction. Underwater noise can propagate over tens of kilometers, and auditory injury to marine mammals has been documented within a few hundred meters of the pile-driving location, with behavioral disturbance occurring at ranges of several tens of kilometers (Madsen et al., 2006). Field measurements in Danish waters confirmed that impulsive noise poses an auditory injury risk to the protected harbor porpoise (*Phocoena phocoena*) population in Scotland's Moray Firth at distances of approximately 100 m, and a behavioral disturbance risk at distances of up to 50 km (Thomsen et al., 2006). The intensity of impulsive noise varies substantially with monopile diameter and driving method; in current offshore wind projects using large monopiles exceeding 5 m in diameter, underwater sound pressure at a reference distance of 1 m can reach 240 dB re 1 μPa, a level capable of exceeding the marine mammal noise standard under South Korea's Marine Environment Management

Act (190 dB re 1 μPa) at distances of several tens of kilometers. Pile-driving noise can induce widespread behavioral and physiological effects across fish, marine mammals, and marine invertebrates, and low-frequency noise during long-term operational phases may also exert chronic effects on benthic ecosystems (Green et al., 2022). The near-total absence of systematic underwater noise assessment in South Korea's former assessment framework is therefore a particularly serious concern in this context (Oh et al., 2021).

2) Electromagnetic field (EMF) effects from submarine cables

The effects of EMF generated by offshore wind farm submarine transmission cables on marine organisms have attracted growing attention in international research. In the vicinity of submarine cables, magnetic field intensity within 1 m typically reaches 0.1–5 mT (millitesla), a level sufficient to induce behavioral responses in marine species possessing electrosensory receptors, including fish, cephalopods, and crustaceans. It has been experimentally confirmed that EMF generated by high-voltage direct current submarine cables produces measurable behavioral effects on benthic cartilaginous fish possessing electrosensory receptors, specifically thornback rays (*Leucoraja erinacea*) (Hutchison et al., 2020). Research published in the ICES Journal of Marine Science has further reported that cable EMF may induce attraction behavior in the commercially important edible crab (*Cancer pagurus*) and potentially alter the composition and distribution patterns of benthic communities (Dannheim et al., 2020). A life cycle assessment-based synthesis analysis confirmed that EMF represents a major pathway through which offshore wind development can disrupt the foraging, orientation, and migratory behavior of fish and invertebrates (Li et al., 2023). South Korea's West Sea coast encompasses major fishery grounds for electrically sensitive species such as common tonguefish and skates, making the potential consequences of EMF impacts on commercial fisheries a particular concern. Yet systematic assessment of EMF effects in South Korean environmental review has been virtually absent (Oh et al., 2021).

3) Bird collision and habitat disturbance

Bird collision and habitat disturbance rank among the most significant biodiversity impacts of offshore wind development. Analysis of 20 European offshore wind farms covering avoidance and collision responses across bird species found that reactions ranged from complete avoidance of the wind farm area to active attraction, with both habitat loss and collision mortality at levels that cannot be dismissed (Dierschke et al., 2016). Environmental assessment practice for offshore wind projects in UK waters established a system designating a broad list of vulnerable species—including northern gannets (*Morus bassanus*), duck species, and diving birds—as collision and disturbance sensitive, and mandating quantitative impact assessment for all such species (Bradbury et al., 2014). Post-commissioning monitoring at the Horns Rev offshore wind farm in Denmark documented large-scale avoidance behavior by scoters (*Melanitta* spp.) and other sea ducks, resulting in habitat fragmentation effects affecting hundreds of thousands of individuals (Dierschke et al., 2016). South Korea's West and South Sea coasts lie along the globally significant East Asian–Australasian Flyway, with the primary staging and wintering areas of

internationally protected species—including the Baikal teal (*Anas formosa*), bean goose (*Anser fabalis*), and oystercatcher (*Haematopus ostralegus*)—substantially overlapping with proposed offshore wind sites. Despite this, population-level quantitative assessment of bird collision risks was absent from domestic assessment practice under the former framework (Oh et al., 2021).

4) Fisheries and social conflicts

Analysis of the offshore wind siting conflict in Yeonggwang-gun, South Jeolla Province, through the lens of energy justice demonstrated that all four tenets of energy justice—distributional, procedural, recognition, and restorative—had been violated. The root causes of project failure were identified as the top-down pursuit of development without prior consultation with fishing communities and the absence of scientifically grounded compensation standards for fisheries impacts (Park et al., 2024). Analysis of the public dialogue process in a Tongyeong offshore wind case similarly found that participation in the siting decision process, adequate consideration of fisheries damages, and provision of sufficient information were the core determinants of community acceptance (Park et al., 2022). Research on public acceptance of a large-scale offshore wind project also confirmed that fishing communities' concerns about economic losses and restrictions on access were the primary drivers of opposition (Kim et al., 2020). The structural roots of these conflicts lie in three deficiencies of the former environmental assessment system: (1) systematic analysis of the spatial overlap between fishing activity distributions and project areas was not required; (2) quantitative assessment of fisheries impacts and development of compensation standards were not mandated as assessment obligations; and (3) procedures guaranteeing meaningful participation by fishing communities in the permitting process were absent. It has been reported that such conflicts with fishing communities contributed to the withdrawal of major European offshore wind developers from the South Korean market, generating tangible adverse effects across the industry (Korea Times, 2024).

The new environmental assessment framework under the offshore wind special act

1. The planned-site system and the two-tier environmental assessment design

As the Offshore Wind Special Act transitions from the former private sector-led, site-by-site approach to a government-led planned-site system, it establishes a two-tier Environmental Assessment framework suited to this new site-selection procedure. Article 26 provides a special exception enabling developers to undergo a single "Environmental Assessment" prescribed by the Special Act in lieu of separate EIA and MEIS procedures. This integrated Environmental Assessment operates in two stages aligned with the phased structure of the planned-site process: (1) a Preliminary Environmental Survey at the Preliminary Zone stage, and (2) a Detailed Environmental Assessment at the Development Zone stage.

2. The location information network and preliminary environmental survey

The first environmental gateway in the planned-site process is the Location Information Network (location information system), jointly developed and operated by the Ministry of Climate, Energy and Environment and the Ministry of Oceans and Fisheries. This system integrates into a single database information on marine protected areas, biodiversity status, fishing activity distribution, migratory bird flyways, marine mammal habitats, military operational areas, and maritime traffic routes, providing the basis for a first-stage screening prior to Preliminary Zone designation. While this system shares a conceptual framework similar to the seabed geological and environmental mapping system developed by the Danish Energy Agency (DEA) from 2022 onward (DEA, 2024), Article 9 of the Enforcement Decree does not specify the types of environmental information that must be included in the Location Information Network, data quality standards, or update cycles—raising concerns that the adequacy of the system's environmental information content cannot be guaranteed. The operational significance of this gap is demonstrated by the Danish experience: the DEA's environmental mapping project required three years (2022–2025) and collaboration across three research institutions before the dataset was deemed sufficiently reliable for plan-level screening (DEA, 2024). Without equivalent data quality benchmarks and update cycles codified in Article 9 of the Enforcement Decree, the Location Information Network risks replicating the blind spots documented in the former dual-track system—particularly regarding migratory bird flyway data and marine mammal habitat ranges—thereby undermining the scientific foundation of the entire two-tier assessment framework. Once designated as a Preliminary Zone, the government conducts a Preliminary Environmental Survey directly (Article 4 of the Enforcement Ordinance and Annex), investigating marine environmental conditions, marine avifauna, marine mammals, seabed topography and geology, and the status of protected species and designated areas, to determine the suitability of the sea area for offshore wind development.

3. The detailed environmental assessment at the development zone stage and key special provisions

Developers must submit a Detailed Environmental Assessment report when applying for Development Zone designation, with results communicated following deliberation by the Environmental Assessment Consultative Body (Article 28 of the Enforcement Decree, comprising the Ministries of Climate, Energy and Environment, Environment, Oceans and Fisheries, National Defense, and Interior and Safety, together with relevant experts) and consultation with the Ministers of Environment and Oceans and Fisheries. The Detailed Assessment report must cover: (1) meteorological, hydraulic, and hydrological conditions; (2) marine ecosystems (macroalgae, fish, benthos, plankton); (3) marine mammals; (4) avifauna and migratory routes; (5) marine landscape; (6) noise, vibration, and EMF; (7) fishery resources and fishing activities; (8) socioeconomic conditions; and (9) community acceptance assessment (Annex to Article 4 of the Enforcement Ordinance).

The most pivotal—and controversial—special provision is Article 32(4) of the Enforcement Decree. This provision permits data collected during the government-led Preliminary Environmental Survey at the Preliminary Zone stage to substitute for Detailed Assessment data on an item-by-item basis, provided the preliminary data satisfies 50% or more of the standard survey period (typically two years) required for the Detailed Assessment. The institutional intent is to theoretically reduce developers' environmental review period from over 30 months to 12–15 months. However, for this provision to function without diminishing environmental protection standards, the quality of the government's preliminary survey must genuinely approach that of a developer-conducted detailed assessment, and a supplementary survey mechanism must operate to reflect ecological changes between the preliminary and detailed assessment phases (Bailey et al., 2014).

4. Integrated permitting through deemed authorization

Beyond the Environmental Assessment, the Offshore Wind Special Act provides that upon selection as a Development Zone operator, developers may have 42 permits across 28 statutes administered by 10 ministries processed simultaneously as deemed authorizations at the time of implementation plan approval (Article 22). Coordinated consultation with the Ministry of Oceans and Fisheries, Cultural Heritage Administration, Ministry of National Defense, and other relevant ministries through the Offshore Wind Power Committee under the Prime Minister is expected to dramatically shorten the individual inter-ministerial consultation procedures that previously consumed several years under the site-by-site approach (EEAS, 2024).

Results

1. The planned-site system and resolution of siting conflicts

The planned-site system introduced by the Offshore Wind Special Act represents an approach aimed at fundamentally resolving the structural conflicts that have characterized the siting process. Under the former site-by-site approach, private developers selected sites primarily on the basis of profitability and only subsequently sought environmental review and community acceptance, with the result that conflicts with fishing communities, intrusions into military operational areas, and opposition from environmental groups were concentrated in the post-project-initiation phase. Such fisheries conflicts have been reported as contributing to the withdrawal of major European offshore wind developers from the South Korean market, inflicting tangible damage across the industry (Korea Times, 2024), while the absence of inter-ministerial coordination and unclear site selection procedures have been identified as core sources of investor uncertainty (EEAS, 2024).

Under the planned-site system, the government proactively identifies Preliminary Zones by comprehensively considering wind resources, environmental impacts, fishing activities,

maritime traffic, and military operational suitability on the basis of the Location Information Network. Military operational concerns are addressed through prior consultation with the Ministry of National Defense before Preliminary Zone designation, eliminating the burden and uncertainty that developers previously faced in conducting individual Ministry of National Defense consultations. Fisheries and community acceptance issues are addressed through local government-led public-private consultative councils following Preliminary Zone designation, with fishing communities and local residents mandated to comprise at least 50% of council membership (Article 15 of the Enforcement Decree).

This approach partially aligns with the core determinants of community acceptance—early participation, adequate consideration of fisheries impacts, and sufficient information provision—identified through empirical research (Park et al., 2022, 2024). However, the failure to explicitly include environmental specialists and environmental organizations in the composition of public-private consultative councils (Article 15 of the Enforcement Decree) represents a significant limitation. The institutional exclusion of actors representing environmental interests from consultative structures risks structurally subordinating environmental conservation values to economic interests.

2. Analysis of key issues in the environmental assessment framework

1) Substitution of preliminary survey data for detailed assessment and concerns about substantive rigor

The substitution provision of Article 32(4) of the Enforcement Decree occupies the most central position among all contested environmental provisions of the Special Act. The impact of this provision's operation on the substantive thoroughness of environmental assessment hinges on two critical conditions. First, the quality and duration of the government-conducted Preliminary Environmental Survey must genuinely approach the standard of a developer-led Detailed Assessment. Second, a supplementary survey mechanism must operate to systematically account for ecological changes between the preliminary and detailed assessment phases—particularly seasonal fluctuations and changes to the marine environment attributable to climate change.

It has been emphasized that baseline surveys of avifauna and marine mammals should be stipulated as a prerequisite for offshore wind project permitting, and that broad-scale strategic-level surveys can supplement but cannot substitute for project-level detailed assessments. In particular, because the spatial extent of potential biological effects from offshore wind projects may extend far beyond the development footprint, the spatial scope of baseline data collection should be determined independently at the project-level assessment stage (Bailey et al., 2014). This principle is operationalized in the EU SEA Directive (Directive 2001/42/EC) as the hierarchical linkage principle between strategic-level and project-level assessment, and requires that the categories and conditions for permissible substitution under Article 32(4) be rigorously specified through subordinate ministerial notice. The structural inadequacy of the 50% survey-period threshold is further demonstrated by the biological demands

of migratory species assessment: Bailey et al. (2014) established that reliable population-level baseline data for migratory birds and marine mammals requires a minimum of two full annual cycles to capture seasonal variation, inter-annual fluctuation, and climate-driven distributional shifts. A preliminary survey satisfying only 50% of the standard two-year survey period—equivalent to approximately one year—may therefore systematically fail to capture entire seasonal migration windows, rendering the substituted data structurally insufficient for population-level collision risk modelling. Given that the Preliminary Zone designation may precede the Detailed Assessment stage by two to four years, the ecological conditions recorded in the preliminary survey cannot be assumed to remain representative at the time of project-level assessment, further undermining the scientific validity of unrestricted data substitution.

2) Narrowing of avifaunal survey scope: scientific evidence and regulatory concerns

The restriction of avifaunal survey scope to "marine bird species" in the Annex to Article 4 of the Enforcement Ordinance, excluding migratory waterfowl such as Anatidae (ducks and geese) from mandatory detailed survey requirements, is at odds with the current trajectory of international offshore wind environmental assessment research. Anatidae species—including the mallard (*Anas platyrhynchos*), common pochard (*Aythya ferina*), common merganser (*Mergus merganser*), and greater scaup (*Aythya marila*)—are winter migratory birds whose movement corridors substantially overlap with proposed offshore wind sites along South Korea's West and South Sea coasts, and are classified as species at elevated risk of turbine collision and habitat disturbance due to their offshore rafting behavior.

Large-scale avoidance behavior by scoters (*Melanitta* spp.) and other sea ducks at the Horns Rev offshore wind farm in Denmark has been documented, resulting in habitat fragmentation effects affecting hundreds of thousands of individuals (Dierschke et al., 2016). Analysis of 20 European offshore wind farms confirmed widespread avoidance responses among ducks and diving birds, with collision mortality at non-negligible levels in certain species (Dierschke et al., 2016). UK guidelines for avifaunal EIA in offshore wind projects have proposed a system classifying ducks and diving birds as explicitly identified vulnerable species and mandating quantitative impact assessment (Bradbury et al., 2014). Given these international research trends, the explicit exclusion of Anatidae from mandatory survey requirements in the Enforcement Ordinance is scientifically inadequate.

3) Exemption from reassessment for design modifications below 30%

Article 34 of the Enforcement Decree exempts developers from the obligation to repeat Environmental Assessment when modifying turbine layout, foundation structure, or submarine cable routes following Development Zone designation, provided the modification is less than 30% of the originally approved design. The fundamental problem with this criterion is that the numerical threshold of 30% of design capacity fails entirely to reflect location-specific and qualitative changes in environmental impact. Offshore wind projects' bird collision and habitat disturbance effects are more sensitive to changes in turbine position and ecological context

than to absolute turbine numbers (Dierschke et al., 2016). A project of 100 MW (20 turbines of 5 MW each) could relocate up to six turbines without exceeding the 30% threshold, yet if the new turbine positions intersect a migratory flyway or encroach on a marine protected area boundary, the qualitative environmental impact would differ fundamentally. This asymmetry between volumetric and locational change is grounded in the ecological concept of sensitivity thresholds: within heterogeneous marine landscapes, small spatial displacements can produce disproportionately large ecological responses when they cross habitat boundaries or overlap with critical life-stage areas—such as migratory staging sites, foraging hotspots, or spawning grounds (Bailey et al., 2014; Dierschke et al., 2016). Marine ecological risk is therefore inherently spatial in character, and a purely quantitative capacity-ratio threshold is epistemologically ill-suited to capture this spatial dimension. This is precisely the principle that underpins the UK's 'Material Change' standard, which determines reassessment obligations on the basis of substantive environmental impact change rather than modification volume—a regulatory philosophy that South Korea's Article 34 has yet to incorporate.

Comparatively, the DEA conducted separate environmental reviews every time the designated area was adjusted—from 440 km^2 to 286 km^2—during the Thor offshore wind farm SEA process (DEA, 2021). The UK's "Material Change" standard is determined by whether the modification produces a substantive change in environmental impact, rather than by the volume of modification—a fundamentally different philosophical basis from South Korea's Enforcement Decree Article 34, which relies on a simple capacity ratio. It has similarly been emphasized that in EIA frameworks for deep-water floating offshore wind facilities, reassessment obligations should be determined on the basis of whether the design modification produces a substantive change in environmental impact (Farr et al., 2021).

4) Insufficient post-commissioning monitoring obligations

The Special Act and its subordinate legislation do not contain adequate specific mandatory provisions for post-commissioning environmental monitoring. The environmental impacts of offshore wind projects occur across the full project lifecycle—pre-construction, construction, operation, and decommissioning—and the magnitude of actual impacts cannot be ascertained without long-term operational-phase monitoring data (Bailey et al., 2014). The accumulation of operational-phase monitoring data is also emphasized as the evidence base for scientifically upgrading future project environmental assessment standards (Green et al., 2022). In Denmark and the United Kingdom, four-stage mandatory monitoring frameworks have been legally established, encompassing pre-construction baseline surveys, construction-phase noise monitoring, operational-phase monitoring of avifauna, marine mammals, and benthic ecosystems, and decommissioning-phase restoration monitoring (DEA, 2021). In contrast, post-commissioning monitoring under South Korea's Special Act framework is largely implemented through Environmental Assessment consultation conditions rather than mandatory statutory obligations, with monitoring items, periodicity, and public disclosure requirements not specified in legislation—raising doubts about its effectiveness (Maeng et al., 2013).

3. Comparative analysis of offshore wind environmental assessment frameworks in major countries

1) Denmark's integrated strategic environmental assessment framework

Denmark mandates SEA at the plan level for offshore wind zone designation under the EU SEA Directive (Directive 2001/42/EC), operating a two-tier system hierarchically linking SEA to project-level EIA. During the Thor offshore wind farm (2020–2021) SEA process, the DEA reduced the initial candidate area from 440 km^2 to 286 km^2 through public consultation and stakeholder engagement, applying criteria for exclusion of areas of marine avifauna, marine mammal, and fisheries sensitivity (DEA, 2021). The Danish offshore wind potential screening and environmental mapping project launched in 2022, developed in collaboration with Aarhus University, DTU Vind, and GEUS, exemplifies an advanced approach to pre-identifying environmentally sensitive sea areas and incorporating them into long-term development roadmaps (DEA, 2024). The 2024 North Sea I zone plan notably operated a transparent SEA process that publicly disclosed minimum (5,000 MW) and maximum (17,445 MW) deployment scenarios based on environmental assessment results.

The core of Denmark's SEA framework is that excluding environmentally sensitive sea areas at the broad plan level substantially simplifies the environmental issues requiring resolution at the project-level EIA stage—enabling shorter EIA processing periods while maintaining higher levels of environmental protection. This institutionally operationalizes the principle that strategic-level surveys complement rather than substitute for project-level detailed assessments, and represents a fundamentally different approach from the substitution provision of Article 32(4) of South Korea's Enforcement Decree.

2) The United Kingdom's strategic environmental assessment and habitat regulations assessment framework

The United Kingdom has systematically conducted SEA for offshore energy development plans since 2001, completing 11 SEA studies by 2018. Additionally, through Habitat Regulations Assessment (HRA), quantitative assessment of bird collision and disturbance impacts is mandated for offshore wind projects that may affect Special Protection Areas (SPAs). The avifaunal impact assessment framework adopted by the UK Environment Agency provides for quantitative assessment of all vulnerable species, setting a broad list of collision-risk species including gannets, ducks, and diving birds (Bradbury et al., 2014). The UK's "Material Change" standard, which determines reassessment obligations on the basis of substantive changes in environmental impact rather than the volume of modification, reflects a fundamentally different philosophy from South Korea's Enforcement Decree Article 34, which determines obligations according to a simple capacity ratio (Dierschke et al., 2016).

3) Assessment of the South Korean framework

South Korea's integrated Environmental Assessment framework under the Offshore Wind Special Act shares the basic logic of the Danish and UK SEA concepts—namely the principle

that broad-scale environmental screening at the plan level complements and streamlines environmental review at the project level. The critical distinction, however, lies in the difference between "substitution" and "complementation." In advanced SEA frameworks, plan-level environmental assessment does not substitute for project-level detailed assessment; both tiers remain hierarchically linked while preserving their functional independence. By contrast, the special provision of Article 32(4) of the Enforcement Decree permits preliminary survey data to "substitute for" detailed assessment data, risking departure from this fundamental principle. The narrowing of avifaunal survey scope (excluding Anatidae), the exemption for modifications below 30%, and the insufficient mandatory monitoring obligations likewise represent elements lagging behind international standards.

4. Policy implications and directions for institutional reform

1) Statutory codification of the complementary linkage principle between preliminary and detailed assessments

The scope of permissible substitution under Article 32(4) of the Enforcement Decree should be strictly circumscribed, or the categories of permissible substitution should be specified through subordinate ministerial notice, to prevent the Detailed Assessment from becoming a formality. Concretely, items for which preliminary survey data may substitute should be limited to physical characteristics such as seabed topography, geology, and meteorological, hydraulic, and hydrological conditions, while biodiversity-related items—including avifauna, marine mammals, and benthic ecosystems—should be explicitly required to remain subject to developer-led detailed surveys. The broad-scale and project-level detailed surveys should be hierarchically linked while preserving their functional independence (Bailey et al., 2014).

2) Expansion and standardization of avifaunal survey items

The avifaunal survey items in the Annex to Article 4 of the Enforcement Ordinance should be expanded to encompass the full range of migratory waterfowl, including Anatidae, with standardized survey protocols developed to reflect seasonal movement corridors and offshore rafting behavior. Assessment methodology quantifying bird collision risks at the population level—including collision risk models—should be incorporated into assessment guidelines (Bradbury et al., 2014; Dierschke et al., 2016). Procedures for examining overlap with avian movement corridors at the Preliminary Zone selection stage should also be specified in Location Information Network operational guidelines.

3) Reform of design modification reassessment standards

The current 30% capacity threshold should be supplemented or replaced by qualitative environmental impact change criteria. Provisions should be added mandating Environmental Assessment regardless of modification magnitude for changes in proximity to ecologically sensitive elements such as protected species habitats, avian movement corridors, and marine protected area boundaries. A standard guideline for determining whether a modification produces a sub-

stantive change in environmental impact should be developed as a joint ministerial notice by the Ministry of Environment and Ministry of Oceans and Fisheries (Farr et al., 2021).

4) Ensuring environmental specialist participation in public–private consultative councils

The composition standards for public-private consultative councils under Article 15 of the Enforcement Decree should be amended to guarantee the institutional participation of marine ecology specialists and representatives of environmental civil society. To institutionalize the recognition justice principle—that the voices of diverse stakeholders should be reflected equally in decision-making processes—the proportion of environmental expert participation and voting procedures should be explicitly specified in legislation (Park et al., 2022).

5) Legal mandatory monitoring and public disclosure framework

A four-stage post-commissioning monitoring framework spanning pre-construction, construction, operation, and decommissioning should be mandated in legislation, with periodic monitoring of bird collisions, marine mammal dynamics, benthic ecosystem changes, and underwater noise levels, alongside public disclosure obligations. The accumulation of operational-phase monitoring data constitutes the evidentiary basis for scientifically upgrading future project environmental assessment standards (Green et al., 2022). EMF monitoring in particular should be mandatorily incorporated from the early operational phase, given the uncertainties regarding benthic organism impacts identified in research (Dannheim et al., 2020; Hutchison et al., 2020). Monitoring results should be integrated into the Location Information Network for use as environmental screening data in subsequent Preliminary Zone designations.

Conclusion

The Offshore Wind Special Act represents a landmark legislative transformation aimed at fundamentally reforming the structural problems of the former dual-track environmental assessment system—inter-ministerial inefficiency, haphazard private-sector site selection, and reactive stakeholder conflict management—and its direction in introducing a government-led planned-site system and an integrated Environmental Assessment framework has been positively received by domestic and international experts (EEAS, 2024; Windpower Monthly, 2025). In particular, the planned-site system constitutes a structural improvement that proactively incorporates the determinants of community acceptance identified through empirical research (Park et al., 2022, 2024), and may be evaluated as a meaningful step forward from an energy justice perspective.

Nevertheless, a number of subordinate regulatory provisions—the substitution of preliminary environmental surveys for detailed assessments (Article 32(4) of the Enforcement Decree), the narrowing of avifaunal survey scope (Annex to Article 4 of the Enforcement Ordinance), the exemption from reassessment for modifications below 30% (Article 34 of the Enforcement Decree), the exclusion of environmental specialists from public-private con-

sultative councils (Article 15 of the Enforcement Decree), and the inadequacy of mandatory monitoring obligations—raise concerns about substantive diminution of environmental assessment rigor. Domestic and international scholarship consistently warns that, in the absence of rigorous assessment and monitoring, the core environmental impacts of offshore wind development—bird collisions, underwater noise, EMF, and fisheries conflicts—can inflict real and lasting harm on marine ecosystems (Bailey et al., 2014; Green et al., 2022; Maeng et al., 2013; Oh et al., 2021). The cases of Denmark and the United Kingdom have institutionally demonstrated that a hierarchically linked framework combining broad-scale SEA with project-level EIA can reconcile speed with environmental protection.

To translate the institutional reform directions proposed in this paper into actionable regulatory outcomes, this study concludes with five concrete benchmarks for legislative and administrative reform. First, Article 32(4) of the Enforcement Decree should be amended to restrict data substitution strictly to physical environment items (seabed topography, meteorology, hydrology), while explicitly mandating developer-led surveys of at least 24 months for biodiversity-related items (avifauna, marine mammals, benthos). Second, the avifaunal survey annex of the Enforcement Ordinance should be revised to include all Anatidae and diving bird species present on the East Asian–Australasian Flyway, with collision risk models (e.g., Band model) applied as a standardized methodology. Third, Article 34 of the Enforcement Decree should be amended to add a qualitative trigger clause: any design modification that relocates turbines within 500 m of a marine protected area boundary, a Ramsar wetland buffer zone, or a documented migratory bird staging area shall require mandatory reassessment regardless of modification magnitude. Fourth, Article 15 of the Enforcement Decree should mandate that at least 20% of public-private consultative council membership be drawn from credentialed marine ecology specialists or recognized environmental civil society organizations. Fifth, the Special Act should be amended to introduce a legally binding four-stage monitoring framework with annual reporting obligations and public disclosure via the Location Information Network, covering bird collision rates, marine mammal acoustic disturbance levels (measured against the 190 dB re 1 μPa standard under the Marine Environment Management Act), benthic community change indices, and EMF intensity at cable crossing points. The incorporation of these provisions into the forthcoming ministerial guidelines for Environmental Assessment standards would align South Korea's regulatory framework with international best practice and provide the legal certainty necessary to support both the 14.3 GW deployment target and sustained marine ecosystem conservation. In particular, as empirical evidence from actual Environmental Assessment operations under the Special Act accumulates following the designation of the first Preliminary Zones, follow-up empirical research addressing the issues raised in this paper will be essential.

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