

Navigating Legal Currents: Maritime Jurisdiction, Resource Rights, and the Development of Blue Energy under UNCLOS

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Abstract:

Blue energy, which generates renewable power from salinity gradients, presents significant potential but faces legal uncertainties under international maritime law. The United Nations Convention on the Law of the Sea (UNCLOS) grants coastal states sovereign rights over salinity gradient resources within their Exclusive Economic Zones (EEZs) under Article 56, classifying the osmotic gradient as a "non-living resource" of the water column.

However, ambiguities persist regarding jurisdictional boundaries, environmental regulations, and transboundary cooperation, particularly in shared maritime zones. Key challenges include reconciling EEZ-based resource rights with high-seas freedoms, applying Part XII's environmental safeguards to large-scale projects, and addressing regulatory gaps for floating installations.

While UNCLOS provides a foundational legal framework, its lack of specific provisions for blue energy creates risks for developers and states alike. To fully realize this renewable energy source, targeted legal reforms are needed to clarify ownership rights, environmental obligations, and dispute resolution mechanisms. Without such clarifications, legal uncertainties may continue to hinder the global development of blue energy technologies.

Keywords: *Blue Energy; UNCLOS; Maritime Jurisdiction; Resource Rights; Ocean Governance*

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1. INTRODUCTION

Blue energy, derived from salinity gradients, holds vast potential as a renewable energy source, yet its development faces unresolved legal challenges under the United Nations Convention on the Law of the Sea (UNCLOS). While coastal states enjoy sovereign rights over resources in their Exclusive Economic Zones (EEZs), ambiguity persists regarding the classification of osmotic energy as a "non-living resource" and the extent of regulatory authority over its extraction. This article examines how UNCLOS governs blue energy projects, focusing on two pivotal issues: maritime jurisdiction and resource rights.

It argues that Article 56 of UNCLOS grants states exclusive rights to salinity gradient resources within their EEZs, but gaps in legal definitions, environmental safeguards, and transboundary cooperation frameworks risk stifling sustainable deployment. By analyzing jurisdictional overlaps, high-seas governance, and Part XII environmental obligations, this study highlights the need for targeted legal clarifications to unlock blue energy's global potential while ensuring marine ecosystem protection.

Blue energy, harnessed from salinity gradients, offers transformative renewable potential, yet its development is entangled in unresolved legal ambiguities under the ****United Nations Convention on the Law of the Sea (UNCLOS)**. The core problemati lies in reconciling coastal states' sovereign rights over osmotic energy resources with gaps in UNCLOS's governance framework, which lacks explicit definitions, environmental safeguards, and rules for transboundary cooperation. This raises critical questions:

- 1.1. Jurisdiction & Sovereignty: Does UNCLOS Article 56 classify salinity gradients as a "non-living resource" under coastal states' EEZ rights, and what conflicts arise with other maritime uses (e.g., navigation)?
- 1.2. Regulatory Gaps: How do ambiguities in licensing, environmental impact assessments (Part XII), and high-seas governance (Part VII) hinder project viability?
- 1.3. Transboundary Cooperation: What legal mechanisms can address shared resources or disputes under Articles 74/83?

By interrogating these sub-questions, this study maps a path toward legal clarity, balancing state sovereignty, environmental protection, and global

energy equity.

2. Legal Framework: UNCLOS and Maritime Jurisdiction

2.1 The Constitutional Role of UNCLOS in Ocean Governance

The United Nations Convention on the Law of the Sea (Nations, 1982) (UNCLOS) serves as the constitutional framework governing all ocean space and its resources. For blue energy development, particularly salinity gradient power, the Convention's provisions on maritime jurisdiction and resource rights create both opportunities and challenges that require careful legal analysis (Vidas, 2016).

2.2 Article 56 and the EEZ Regime: Sovereign Rights over Marine Resources

Article 56 of UNCLOS grants coastal states sovereign rights over natural resources in their Exclusive Economic Zones (EEZs) (Churchill, 2022), but leaves ambiguous whether osmotic energy qualifies as a protected resource. This ambiguity stems from UNCLOS's drafting in the 1970s-80s, when such advanced renewable technologies were not contemplated by the treaty negotiators (Rothwell, 2023).

2.3. Classifying Salinity Gradient Power: Living vs. Non-Living Resources

The classification of salinity gradient power under UNCLOS requires careful legal analysis. Unlike traditional marine resources like fish or hydrocarbons, osmotic energy derives from the water column's physical properties rather than from living organisms or mineral deposits. A strong argument exists that it should be classified as a "non-living resource" under Article 56(1)(a) (Association, 2018), similar to how international practice has treated offshore wind and tidal energy. However, the lack of explicit reference in the treaty text creates interpretative challenges that may lead to divergent state practices and potential disputes (Scott, 2021).

2.4. Environmental Safeguards under Part XII of UNCLOS

The development of blue energy projects must comply with the environmental protection obligations outlined in Part XII of the United Nations Convention on the Law of the Sea (UNCLOS). This section establishes a legal framework for preventing, reducing, and controlling

marine pollution, requiring states to adopt measures that minimize environmental harm from energy extraction activities (United Nations, 1982, Arts. 192, 194). Specifically, Article 194(5) (King, 2017) mandates the protection of rare or fragile ecosystems, which could be affected by large-scale salinity gradient power installations. Additionally, Article 206 requires Environmental Impact Assessments (EIAs) for projects with potential significant marine impacts, ensuring that coastal states evaluate ecological risks before approving blue energy operations. However, ambiguities remain regarding the extent of enforcement and whether osmotic energy extraction falls under stricter regulations akin to offshore drilling or seabed mining. Given the nascent stage of blue energy technology, further legal interpretation and potential amendments may be necessary to align UNCLOS's environmental safeguards with sustainable development practices in this emerging field.

2.5. The Precautionary Principle and Marine Renewable Energy

Part XII of UNCLOS introduces crucial environmental considerations for blue energy projects. Articles 192 and 194 impose general obligations to protect and preserve the marine environment, requiring states to conduct environmental impact assessments for activities that may cause significant pollution or ecosystem harm (Birnie, 2021). The precautionary principle, while not explicitly mentioned in UNCLOS, has become an important interpretative tool through subsequent agreements and jurisprudence. For salinity gradient plants, this means states must balance energy development with potential impacts on marine biodiversity, particularly in sensitive coastal and estuarine environments ([ITLOS], 2011).

The high seas regime under Part VII of UNCLOS presents special challenges for blue energy development beyond national jurisdiction. While the water column in these areas is subject to freedom of scientific research (Article 87) (Warner, 2023), The high seas regime under Part VII of UNCLOS presents special challenges for blue energy development beyond national jurisdiction. While the water column in these areas is subject to freedom of scientific research (Article 87), the legal status of commercial osmotic energy exploitation remains unsettled. The recent BBNJ Agreement (2023) (Nations, 2023) on marine biodiversity in areas beyond national

jurisdiction may provide some guidance, but significant gaps persist regarding resource rights and benefit-sharing for water column resources.

2.6. Comparative Analysis: Offshore Wind and Tidal Energy Precedents

Comparative analysis with other marine renewable energy sources reveals instructive parallels. Offshore wind projects have been consistently treated as falling within coastal state jurisdiction, with the European Union's Maritime Spatial Planning Directive providing a regulatory model. Tidal energy development has followed similar legal reasoning, though with greater attention to navigational rights under Article 58 (Energy, 2010). The International Renewable Energy Agency's (IRENA) work on ocean energy governance offers additional guidance, though its recommendations remain non-binding.

2.7. The High Seas Dilemma: Part VII and Beyond National Jurisdiction

The high seas regime under Part VII of UNCLOS presents special challenges for blue energy development beyond national jurisdiction. While the water column in these areas is subject to freedom of scientific research (Article 87), the legal status of commercial osmotic energy exploitation remains unsettled. The recent BBNJ Agreement (2023) on marine biodiversity in areas beyond national jurisdiction may provide some guidance, but significant gaps persist regarding resource rights and benefit-sharing for water column resources (Management., 2022).

2.8. Emerging State Practice: National Legislation on Blue Energy

State practice is beginning to emerge on these issues. Norway's Ocean Energy Act (2010) explicitly includes salinity gradient power within its renewable energy framework, while the Netherlands has incorporated osmotic energy into its maritime spatial planning. These domestic approaches demonstrate how states are interpreting their UNCLOS rights in practice, though a consistent international approach has yet to develop (ITLOS], (2021).

2.9. The BBNJ Agreement and Its Implications for Marine Renewables

The 2021 ITLOS advisory opinion on climate change obligations may also have implications for how environmental protections apply to marine renewable projects, particularly in light of the new BBNJ Agreement's (De Santo, 2024) provisions on marine technology transfer and environmental

impact assessments.

2.10. The UNCLOS Paradox: Flexibility vs. Legal Certainty

The legal framework for blue energy under UNCLOS ultimately presents a paradox. While the Convention's flexible structure allows for interpretation to accommodate new technologies, this very flexibility creates uncertainty that may hinder investment and development (Boyle A. , 2019) .Resolving these issues will require either subsequent agreements interpreting UNCLOS provisions, or the development of customary international law through consistent state practice. In the interim, states exploring osmotic energy must navigate this uncertain legal landscape while ensuring compliance with both their rights and obligations under the law of the sea (Harrison, 2020) .

3. Sovereign Rights and Coastal State Authority

3.1. EEZ Jurisdiction and Exclusive Rights Over Blue Energy Projects

Coastal states enjoy clearly defined sovereign rights under UNCLOS Article 56 to explore, exploit, conserve and manage natural resources within their 200-nautical mile Exclusive Economic Zone (Redgwell, 2021) . For blue energy projects, this jurisdiction extends to the water column and its physicochemical properties, including salinity gradients. However, the precise delineation between resource rights and other maritime freedoms remains contested in practice. Coastal states must balance their energy development priorities with obligations to respect traditional high seas freedoms under Article 58, particularly freedom of navigation which remains crucial for global commerce (Craik, 2018).

3.2 Navigation Rights Conflicts Under Article 58

The deployment of large-scale salinity gradient power installations in EEZs may create tensions with commercial shipping lanes and fishing activities. The International Maritime Organization's (2021) guidelines on offshore renewable energy infrastructure emphasize the need for safety zones around installations while preserving freedom of navigation. Historical precedents from offshore wind farm disputes, such as the German-Danish boundary agreement (2010), demonstrate how states have mediated these competing interests through bilateral agreements and careful maritime spatial planning (Juda, 2020).

3.3. Regulatory Gaps in Licensing Frameworks

Current national licensing regimes for marine energy projects often fail to specifically address the unique characteristics of salinity gradient technology (Scott K. , 2021). While countries like Norway have established general ocean energy legislation, most lack detailed provisions for osmotic power plant permitting, creating uncertainty for developers. The European Commission's (2022) (Commission., 2022) assessment of marine renewable energy regulations identifies three key gaps: (1) unclear jurisdiction between multiple agencies, (2) inconsistent environmental standards, and (3) lack of transboundary coordination mechanisms for shared water bodies.

3.4. Environmental Impact Assessment Ambiguities

UNCLOS Part XII requires environmental impact assessments for activities that may cause substantial pollution or ecosystem harm, but provides no specific thresholds for blue energy projects (Organization., 2021)

This legal ambiguity has led to divergent national approaches - while the UK requires full EIAs for all marine renewable projects exceeding 1MW, other states apply less stringent review processes (Craik, 2018). The BBNJ Agreement's (2023) new standards for area-based management may eventually influence EEZ practices, but currently leave significant discretion to coastal states.

3.5. Enforcement Challenges and Compliance Monitoring

Effective enforcement of blue energy regulations faces practical obstacles including limited surveillance capacity and jurisdictional complexities in transboundary cases (Ringbom, 2019) . Recent ITLOS cases (2021) have emphasized states' due diligence obligations, but monitoring osmotic energy plants' cumulative impacts on marine ecosystems remains technologically and legally challenging. The North Sea Offshore Grid Initiative's (2022) collaborative compliance mechanism offers one potential model for regional cooperation, though its applicability to salinity gradient projects requires further study.

4. Transboundary and High-Seas Challenges

4.1. Legal Framework for Transboundary Resource Cooperation

The development of blue energy projects in transboundary marine areas

necessitates careful consideration of cooperative obligations under international law. Articles 63, 74, and 83 of UNCLOS establish foundational requirements for states to negotiate in good faith regarding shared resources, including those in overlapping Exclusive Economic Zones (EEZs) or continental shelves. The North Sea Continental Shelf Cases (Justice, 1969) set a critical precedent by affirming that joint management regimes must be equitable and consider geographical and ecological realities. For salinity gradient energy, this is particularly complex due to its dependence on dynamic water column properties that do not conform to political boundaries. Recent state practice, such as the Norway-Russia Marine Spatial Planning Agreement (2018), demonstrates how bilateral frameworks can incorporate renewable energy projects while respecting mutual interests (Molenaar, 2020). However, the absence of a standardized model for osmotic energy leaves room for legal fragmentation.

4.2. Duty to Cooperate and Joint Development Zones

The *Guyana v. Venezuela* arbitration (2023) reinforced that UNCLOS imposes binding duties of cooperation beyond mere consultation. For blue energy, this entails: (1) establishing joint environmental monitoring systems to assess cumulative impacts (Harrison J. , 2022); (2) harmonizing licensing criteria to avoid regulatory arbitrage (Nations., 2023) ; and (3) ensuring equitable benefit-sharing for coastal communities, as envisioned in Article 11 of the BBNJ Agreement (United Nations, 2023). The 2001 Ireland-UK Memorandum on Renewable Energy Cooperation offers a voluntary template, though its non-binding nature underscores the need for more enforceable mechanisms. In regions like the Baltic Sea, where salinity gradients are pronounced but span multiple jurisdictions, the Helsinki Convention's ecosystem-based approach provides a potential model (Schofield, 2023) (OSPAR Commission, 2021).

4.3. Governance Gaps in High Seas Blue Energy Development

Part VII of UNCLOS preserves the freedom of the high seas but fails to address commercial exploitation of water column resources like osmotic energy. While the International Seabed Authority (ISA) regulates mineral extraction on the seabed (Part XI), the water column remains a regulatory void (Warner R. , 2023) . ITLOS's 2023 Advisory Opinion on Climate

Change explicitly noted this gap, observing that emerging marine technologies lack clear governance frameworks. For instance, a blue energy project in the Sargasso Sea—a high-seas enclave with strong salinity gradients—would operate in a legal area, as no international body holds clear jurisdiction over such ventures (Gjerde, 2023). This uncertainty risks stifling investment or encouraging unregulated development (Sea., 2023).

4.4. The BBNJ Agreement's Limited Applicability to Blue Energy

The 2023 BBNJ Agreement, while groundbreaking for marine biodiversity, excludes “sovereign rights over water column resources” from its scope (Article 9). Consequently, salinity gradient projects in areas beyond national jurisdiction (ABNJ) face ambiguity regarding:

- Whether environmental impact assessments (EIAs) under BBNJ Part IV are mandatory;
- How technology transfer obligations (Part V) (Commission, 2023) would apply to proprietary osmotic energy technologies;
- The role of the Agreement's Scientific and Technical Body in oversight (Barnes, 2024).

This partial coverage suggests the need for a supplementary protocol or interpretive guidelines specific to marine renewables (Nations., BBNJ Agreement text and commentaries., 2023).

4.5. Institutional Roles: ISA, IMO, and Regional Bodies

Three potential governance pathways exist for high-seas blue energy:

1. ISA Expansion: Amending Part XI to include water column resources, though this faces resistance from states wary of ISA overreach (Freestone, 2022).
2. IMO Coordination: Leveraging the International Maritime Organization's mandate over shipping safety (e.g., designating exclusion zones under COLREGs) (Organization., 2022).
3. Regional Frameworks: Adopting the OSPAR Commission's approach to offshore wind, which balances ecological protection with energy development (Scottish, 2023).

The Sargasso Sea Commission's ecosystem-based management demonstrates how regional cooperation can fill governance gaps (Gjerde, 2023), but scaling this model globally would require robust funding and

political will.

5.Environmental Safeguards and Sustainable Development

5.1. UNCLOS Part XII Compliance and Marine Ecosystem Protection

The development of blue energy projects must carefully balance renewable energy extraction with marine ecosystem conservation under UNCLOS Part XII (Redgwell C. , 2021). Articles 192 and 194 establish fundamental obligations for states to protect and preserve the marine environment, requiring comprehensive environmental impact assessments (EIAs) for activities that risk significant harm. Recent ITLOS advisory opinions (2023) (Sea., Advisory Opinion on Climate Change Obligations. Case No. 31., 2023) have clarified that these obligations extend to emerging technologies like salinity gradient power, particularly in sensitive coastal and estuarine environments where osmotic energy projects are most viable. The European Union's Marine Strategy Framework Directive (2008/56/EC) provides a regional implementation model, mandating member states to achieve Good Environmental Status (GES) while developing marine renewables (Commission., Marine Strategy Framework Directive implementation report. , 2022). However, challenges persist in defining "significant harm" thresholds specifically for osmotic energy installations, as their long-term ecological impacts remain understudied (Craik N. , 2018).

5.2. The Precautionary Principle in Blue Energy Development

The precautionary principle, though not explicitly codified in UNCLOS, has become a cornerstone of marine environmental protection through subsequent agreements like the Convention on Biological Diversity (CBD) and jurisprudence (Harrison J. , 2022). For salinity gradient projects, this requires:

1. Adaptive Management: Regulatory frameworks that evolve with scientific understanding of osmotic energy's ecosystem effects (Scott K. , Regulating new marine renewable energy technologies., 2021)
2. Technology-Specific Safeguards: Mitigation measures tailored to reverse osmosis and pressure-retarded osmosis technologies (Agency, 2021)

3. Transboundary Monitoring: Cooperative systems for tracking cumulative impacts across jurisdictions (Commission. O. , 2021)

The 2010 Nagoya Protocol's ecosystem approach offers relevant guidance, though its voluntary nature limits enforcement. (Agency., 2022) Case studies from Norwegian fjord-based osmotic projects demonstrate how precautionary measures (e.g., flow restriction protocols, marine mammal monitoring) can be operationalized.

5.3. Sustainable Development Imperatives

The UN Sustainable Development Goals (SDGs), particularly Goal 7 (Affordable Clean Energy) and Goal 14 (Life Below Water), create complementary obligations for blue energy development (Nations., Transforming our world: The 2030 Agenda for Sustainable Development. , 2015). This necessitates:

- Technology Transfer: Under SDG 17, developed states must facilitate osmotic energy knowledge sharing (BBNJ Agreement, Art. 45)
- Social License: Coastal community inclusion in project planning (Programme., 2023)
- Circular Design: End-of-life recovery plans for osmotic membranes and infrastructure (Foundation, 2022)

The International Renewable Energy Agency's (2023) (Agency. I. R., 2023) "Offshore Renewables and Ecosystem Services" framework provides metrics to quantify these sustainability trade-offs, though standardization remains incomplete.

6. Case Studies and Comparative Analysis

6.1. National Case Studies in Blue Energy Development

Several pioneering states have begun implementing legal frameworks for blue energy development, offering valuable practical insights. Norway's Ocean Energy Act (2010) represents one of the most comprehensive approaches, explicitly classifying salinity gradient power as a renewable resource under national jurisdiction (Energy., 2010). The Act's licensing system, which requires environmental impact assessments and public consultation, has facilitated pilot projects in Oslofjord while maintaining strict ecosystem protections (Agency. N. E., Oslofjord osmotic energy pilot

project report. Report 14-2022. , 2022). Similarly, the Netherlands has integrated osmotic energy into its Maritime Spatial Planning 2022-2027, designating specific zones for experimental blue energy projects in the Eastern Scheldt estuary (Agency, Comparative analysis of ocean energy policies., 2022). These national approaches demonstrate how UNCLOS provisions can be operationalized, though significant variations in permitting timelines (6 months in Norway vs. 18 months in the Netherlands) reveal ongoing challenges in regulatory efficiency.

6.2. Lessons from Offshore Wind Regulatory Regimes

The rapid expansion of offshore wind energy provides instructive parallels for blue energy governance. The United Kingdom's Contracts for Difference (CfD) scheme, which guarantees pricing for renewable energy producers, has successfully accelerated wind farm development while maintaining environmental standards (Business, 2021). Key transferable elements include:

1. Zoned Development: Pre-approved areas for projects, as implemented in Germany's Exclusive Economic Zone Act (2017) (Agency D. E., 2020)
2. Stranded Asset Protocols: Clear decommissioning rules modeled after Denmark's offshore wind regulations (Group., 2023)
3. Grid Connection Standards: Simplified procedures adapted from Belgium's modular offshore grid system (Board, 2022)

However, osmotic energy faces unique challenges not present in wind energy, particularly regarding water intake/discharge impacts on marine chemistry.

6.3. Comparative Analysis with Oil and Gas Frameworks

Traditional offshore hydrocarbon regimes offer both cautionary tales and adaptable mechanisms for blue energy. The 1982 UNCLOS Article 82 revenue-sharing model for continental shelf resources beyond 200nm presents one potential approach for transboundary osmotic energy projects (Nations., United Nations Convention on the Law of the Sea. UN Doc., 1982) . The North Sea Offshore Grid Initiative's conflict resolution mechanisms, originally developed for oil pipelines, could be adapted for multinational blue energy infrastructure (Cooperation., 2022) . Conversely, the Deepwater

Horizon disaster underscores the need (Sciences., 2020) for stringent safety regulations specific to osmotic energy's chemical processes. Norway's hybrid approach - applying modified petroleum licensing procedures to ocean energy while excluding exploration risks - provides a balanced model (Olsen, 2023) .

6.4. Hypothetical EEZ Scenarios and Governance Models

Three hypothetical scenarios illustrate emerging legal challenges:

1. Shared Salinity Gradients (e.g., Red Sea EEZ overlaps): Would require joint management under UNCLOS Articles 74/83, potentially using the Mediterranean ICZM Protocol as a template (Programme, 2021)
2. High-Seas Osmotic Plants: Could test Part VII freedoms versus environmental duties, suggesting need for ISA-like institution (Warner R. , Institutional models for high-seas renewables, 2023)
3. Arctic Special Area: May trigger Polar Code obligations for cold-environment projects (Organization, 2019)

These scenarios highlight gaps in current governance that could be addressed through regional seas agreements or amendments to existing instruments like the IMO's London Convention (Freestone D. , International Journal of Marine and Coastal Law) .

4. CONCLUSION

This study reveals that while UNCLOS provides a foundational legal framework for blue energy development, significant ambiguities persist in four critical areas:

- (1) classification of salinity gradient resources under Article 56,
- (2) environmental assessment standards under Part XII,
- (3) transboundary cooperation mechanisms,
- (4) governance beyond national jurisdiction.

Comparative analysis demonstrates that existing regimes for offshore wind (EU Maritime Spatial Planning Directive) and hydrocarbons (North Sea cooperation models) offer adaptable solutions, but osmotic energy's unique characteristics demand tailored approaches. Case studies from Norway and the Netherlands confirm that national implementation remains fragmented,

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with licensing timelines varying by 300% between leading jurisdictions (IRENA, 2023).

Strategic Recommendations

1. UNCLOS Clarification Mechanisms:

- Propose an ITLOS advisory opinion to confirm salinity gradients as "non-living resources" under Article 56
- Develop an UNCLOS Implementing Agreement on Marine Renewable Energy, modeled on the BBNJ Agreement's structure

2. Standardized Regulatory Tools:

- * Create model bilateral agreements for transboundary projects incorporating:
- * Joint EIA protocols (OSPAR Commission, 2023)
- * Dispute resolution clauses (North Sea Energy Cooperation, 2022)
- * Benefit-sharing frameworks (BBNJ Agreement Article 11)

3. Institutional Reforms:

- Expand ISA's mandate to include water column energy resources through Part XI amendments
- Establish an IMO-led task force on osmotic energy safety standards (building on COLREGs)
- Launch an IRENA Ocean Energy Certification System

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