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Harnessing Offshore Wind for Sustainable Economic Growth in Nordic Countries: Legal Innovations, Economic Opportunities, SDG and Policy Integration

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Abstract: Offshore wind energy refers to the generation of electricity from wind turbines installed in bodies of water, typically seas or oceans. Sustainable economic growth refers to a mode of economic development that aims to meet the needs of the present without compromising the ability of future generations to meet their own needs. This research investigates the potential of offshore wind energy to drive sustainable economic growth in the Nordic countries. Framed within the context of the UN Sustainable Development Goals (SDGs), particularly SDG 7 on Affordable and Clean Energy, the study explores the interplay between renewable energy development and economic prosperity. The research examines innovative legal measures that can facilitate the development of the offshore wind industry in the Nordic region. This includes analyzing streamlining permitting processes, fostering public-private partnerships, and establishing frameworks for grid integration. By investigating the nexus of legal innovations, economic opportunities, and policy integration, this study aims to provide insights into how the renewable energy sector, particularly offshore wind, can contribute to achieving Sustainable Development Goals (SDGs) while fostering economic prosperity. Finally, the research emphasizes the importance of policy integration for maximizing the benefits of offshore wind development. It analyzes how national and regional policies can be harmonized to create a supportive environment for the industry. This includes considering environmental regulations, spatial planning, and social impact assessments. Through a multidisciplinary approach, this research examines the economic and legal measures necessary to optimize the benefits of offshore wind projects, including job creation, investment attraction, and regional development. By analyzing successful case studies and policy frameworks, this study seeks to offer actionable recommendations for policymakers, industry stakeholders, and researchers to navigate the complex landscape of offshore wind development and ensure its alignment with sustainable economic objectives in the Nordic region.

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1. Introduction

Since signing of ***Helsinki Agreement***, known as the **"Nordic Constitution,"** on March 23rd, 1962 (Treaty, 1962), Nordic Day has been annually celebrated to commemorate Nordic cooperation, recognized as the oldest regional political collaboration globally. Participating in this collaboration are Denmark, Finland, Iceland, Norway, and Sweden, alongside the territories of the Faroe Islands, Greenland, and Åland (Nordic Day 2024 - current economic state of the Nordics, 2024). The Nordic countries have made significant progress in achieving the Sustainable Development Goals (SDGs) outlined in the 2030 Agenda for Sustainable Development. Finland leads globally, followed by Denmark, Sweden, and Norway. The Nordic Model, characterized by robust social welfare systems and democratic political structures, has led to significant progress in poverty reduction, health, education, gender equality, clean energy, economic growth, reduced inequalities, and peace (UNAA, 2023). In Nordic, floating offshore wind has the potential to significantly boost renewable energy capacity in Asia. Unlike Europe, where seabeds consist of sand, silt, and medium to hard clays, The North Seas Energy Cooperation (NSEC), an organization comprising North Sea countries[1] and the Commission, was established to streamline the implementation of offshore renewable energy projects. The Nordics are sustainability natives, home to 12 of the 100 most sustainable companies globally, and have technology leaders in AI, gen AI, and digitization (McKinsey, 2023). In April 2023, seven North Sea member states[2], along with Norway and the UK, endorsed the Ostend Declaration, which sets targets for offshore wind energy deployment at 120 GW by 2030 and 300 GW by 2050. In recent years, offshore wind energy has emerged as a promising renewable energy source, driven by the need to reduce greenhouse gas emissions and mitigate climate change. In transitioning to a sustainable future, wind energy stands out due to its abundance, scalability, and environmental benefits. In 2023, solar overtook renewable hydropower as the largest source of renewable energy capacity globally (1419 GW). Renewable energy contributed to over 43% of the global electric capacity, up from 40% in 2022. Global renewable energy capacity reached an all-time high of 3870 Gigawatts (GW). This is an increase of 473 GW from 2022, marking the largest yearly growth on record[3]. The EU's electricity prices for households in the second half of 2023 were €0.283 per kWh, a decrease from €0.294

[1] Belgium, Denmark, Germany, Ireland, France, Luxembourg, Netherlands, Sweden and Norway.
[2] Belgium, Denmark, Germany, Ireland, France, Luxembourg and Netherlands.
[3]Renewable Energy Capacity Tracker. (April 2024). Energy. Retrieved from https://qery.no/renewable-energy-capacity-tracker/.

in the first half, but still remain at historically high levels, according to Eurostat data[1]. In the heart of Norway's Fosen district, a clash unfolded over Europe's largest onshore wind farm, situated 280 miles north of Oslo.61 The conflict centered on allegations of infringement of indigenous rights and the traditional reindeer farming practices of the Sami people (Sandoval, 2015). EU and Nordic regulations will boost Nordic companies' circularity by increasing compliance and directing value towards circular economy solutions. This offers a competitive advantage by addressing environmental challenges and decoupling growth from adverse impacts, providing both environmental and business benefits (Cornander, et al., 2023). Nordic nations' global soft power, particularly in sustainability, remains strong despite fluctuations. Sweden retains its lead, while Norway surpasses Sweden in sustainable initiatives. Denmark maintains its position in the top 20 soft power nations, and Finland excels in sustainable practices and recommendations. Iceland exhibits notable growth in influence but faces challenges in media perception (Finance, 2024).

1.1. Research Design

The research adopts a multidisciplinary approach aimed at comprehensively examining the complex interplay between legal frameworks, economic dynamics, and policy strategies in the context of offshore wind development in Nordic countries. Our study employs a combination of qualitative and quantitative research methods to analyze existing legal frameworks governing offshore wind projects, assess economic opportunities associated with offshore wind energy, and evaluate the effectiveness of policy integration efforts in promoting sustainable economic growth. Through literature review, legal analysis, economic modeling, and policy evaluation, our research aims to provide insights into the challenges and opportunities of offshore wind development in the Nordic region, identify innovative legal solutions, highlight potential economic benefits, and offer recommendations for policymakers and stakeholders to optimize the contribution of offshore wind energy to sustainable economic growth in the Nordic countries.

1.2. Research Question

Q1: What are the existing legal frameworks governing offshore wind development in Nordic countries, and how do they impact sustainable economic growth?

Q2: How do economic opportunities from offshore wind energy differ among Nordic countries, and what factors contribute to these variances?

[1] Energy. (April 2024). Consumer Energy Prices in Europe: Electricity Prices for Households. Retrieved from https://qery.no/consumer-energy-prices-in-europe/.

Q3: What innovative legal strategies have Nordic countries adopted to address regulatory barriers and advance offshore wind development?

Q4: How does the integration of policies at national and regional levels affect the potential for sustainable economic growth through offshore wind energy in the Nordic region?

Q5: How can the Nordic countries strategically leverage offshore wind energy to achieve sustainable economic growth while effectively integrating legal innovations, addressing environmental goals, and advancing the objectives outlined in Sustainable Development Goal 7 (SDG 7) and other relevant environmental targets?

1.3. Research Objectives

a) Analyze innovative legal measures adopted by Nordic countries to facilitate the development of the offshore wind industry.

b) Identify and assess the economic opportunities associated with offshore wind energy in the Nordic region, including job creation, supply chain development, and export potential.

c) Examine how policy integration strategies at national and regional levels can maximize the economic and environmental benefits of offshore wind development.

2. Literature Review

The harnessing of offshore wind presents a pivotal opportunity for sustainable economic growth in Nordic countries, catalyzing a convergence of legal innovations, economic potentials, and policy integration aimed at advancing Sustainable Development Goals (SDGs). This literature review explores the multidimensional facets of offshore wind development, scrutinizing its legal frameworks, economic prospects, and policy synergies to elucidate its transformative role in fostering sustainable development across the Nordic region. *Cacco, C., et. al., (2024)* (Cacco & Usman, 2024) explores wind energy's historical evolution, technological advancements, economic implications, environmental impact, and socio-political significance, emphasizing its role in mitigating climate change and driving global economic growth. *Liew, M. K. E., et. al., (2024)* (Liew, et al., 2024) explores the rise of offshore wind energy, highlighting its current status, benefits, technological advancements, and future prospects. Key benefits include abundant resources, space utilization, reduced environmental impact, job creation, and enhanced energy security. Technological advancements such as larger turbines and floating wind farms have reduced costs, making offshore wind a competitive alternative to fossil fuels. *Butt, J. (2024)* (Butt, 2024) explores innovative approaches and solutions

driving sustainable economic development, ranging from renewable energy technologies to circular economy practices and social equity initiatives and highlights the advancements in green technologies, economic models, and policy frameworks, the study underscores the transition towards a more sustainable and resilient global economy, envisioning a future where economic growth aligns harmoniously with environmental preservation and social inclusivity. *Staff Writer. (2024)*[1] revealed that 71% of Louisiana's existing workforce in adjacent industries has transferable skills for supporting offshore wind. Louisiana's manufacturing, shipbuilding, and offshore services sectors are well-positioned to transition into offshore wind, leveraging over 100 fabrication assets and substantial expertise. The report of *FSR Global. (2024)*[2] highlighted the crucial juncture of India-EU cooperation in offshore wind, aiming to leverage technological and regulatory advancements for mutual economic and environmental benefits. *Barrington Energy. (2024)*[3] explores offshore wind sector is poised for further growth in 2024 after a record investment year in 2023, promising economic opportunities alongside environmental benefits. Job creation, technological innovation, and market expansion drive the industry's economic empowerment, fostering sustainability and prosperity. *Nasiri, Hamid. (2024)* (Nasiri, 2024) delves into the burgeoning frontier of offshore wind energy, highlighting its promise, challenges, and innovations, emphasizing stronger winds, technological advancements, and global momentum. It underscores the pivotal role of offshore wind turbines in combating climate change and spurring economic growth, advocating for meticulous planning, collaboration, and technological innovations to ensure sustainability and affordability in delivering clean electricity worldwide. *Nordic Council of Ministers. (2023)* (Ministers, 2023) scrutinizes the concept of green growth at the core of sustainable development strategies, exploring the possibility of decoupling economic growth from resource use and environmental impacts. *Raza, A., et. al., (2024)* (Raza, Ali, Tursoy, Seraj & Habeeb, 2024) scrutinized the impact of economic growth, sustainable energy, natural resources, technological innovation, and financial development on the environment in Scandinavian economies. It employed a unique approach, utilizing the Westerlund cointegration and CS-ARDL model to explore the relationships among these factors and estimate both long and short-term effects. *Nuta, Alina Cristina et. al., (2024)* (Nuta, et al, 2024, pp. 1-26) examines the relationship

[1] Staff Writer. (2024, April 25). Harnessing the Gulf: Louisiana's future in offshore wind energy. https://www.environmentenergyleader.com/2024/04/harnessing-the-gulf-louisianas-future-in-offshore-wind-energy/.

[2] FSR Global. (2024, April 17). Harnessing the Wind: Challenges, Opportunities, and Lessons Learned. Retrieved from https://fsrglobal.org/harnessing-the-wind-challenges-opportunities-and-lessons-learned/.

[3] Barrington Energy. (2024, March 15). Investing in the Breeze: The Economic Potential of Offshore Wind Energy. Retrieved from https://www.barrington-energy.com/news/investing-in-the-breeze-the-economic-potential-of-offshore-wind-energy/.

between PM2.5 air pollution and various urban economic and social indicators across 15 European capitals from 2010 to 2017. *Islam, S. S. (2024)* (Islam, 2024) investigates the economic growth of the Nordic region, consisting of eight culturally diverse countries with abundant resources. Despite facing financial crises, these nations have demonstrated resilience, attributing their prosperity to sustainable development, strong social welfare systems, and collaborative regional initiatives. Examining their successful strategies provides valuable lessons for the global community aiming to emulate their achievements. *Velenturf, Anne et. al., (2021)* (Velenturf, et al., 2021) underscores the significance of low-carbon energy infrastructure like wind and solar farms in mitigating greenhouse gas emissions and curbing global temperature rise to 1.5°C. With 5.2GW of offshore wind capacity added globally in 2020, totaling 32.5GW across 162 wind farms, plans for over 200GW more by 2030 are underway. *Butt, J. & Kousar, F. (2023)* (Butt & Kousar, 2023, pp. 150–163) critically examines the efficacy of impact-based regulation (IBR) in attaining environmental objectives, highlighting its reliance on variables such as regulatory structure, enforcement rigor, and stakeholders' compliance disposition and further delves into the complexities surrounding IBR implementation, including the encountered challenges and future prospects. The study further explores the interplay between IBR and international law, the study evaluates its efficacy in meeting environmental targets, drawing insights from case studies of nations adopting IBRs and gauging their adherence to global legal norms. *Nuţă, Florian Marcel et. al., (2024)* (Nuta, Nuta, Ahmed, Duan & Khan, 2024) focuses on fostering ideas and recommendations for enhancing the resilience of economies against climate change. It highlights the importance of involving stakeholders in environmental conservation for sustainable development. Key areas of study include financial stability, healthcare costs, and the correlation between climate change indicators and economic performance. *Känzig, D. R., et. al., (2023)* (Känzig & Konradt, 2023) explores that Denmark, Finland, Sweden, and Norway, where revenue recycling is implemented, carbon taxes are expected to have minimal or insignificant negative economic impacts on factors such as industrial and GDP growth and unemployment. This is attributed to the reduced tax burdens on citizens. *Awogbemi, O., (2023)* (Awogbemi & Von Kallon, 2023) highlights the underutilization of hydropower, solar energy, wind energy, geothermal, nuclear, and ocean energy technologies. Through a SWOT analysis, it identifies the strengths, weaknesses, opportunities, and threats associated with these underutilized energy technologies. The paper proposes strategies aimed at increasing the share of renewable energy technologies in the global energy mix, emphasizing their eco-friendly, sustainable nature, and their contribution to achieving carbon neutrality. *Dilanchiev, Azer et. al., (2024)* (Dilanchiev, Sharif, Ayad & Nuta, 2024) investigates the impact of FDI, renewable energy, and remittances on environmental quality in top remittance-receiving countries. It highlights a positive correlation between FDI and carbon emissions, while renewable energy and remittances exhibit an inverted

U-shaped relationship. Developing countries show improved environmental quality post-threshold for remittances, and renewable energy becomes significant for pollution mitigation beyond a certain stage, suggesting varied policy implications.

The literature is evident that we are at a crucial juncture where legal innovations, economic opportunities, and policy integration will shape sustainable development. The studies reveal the transformative potential of offshore wind energy, highlighting its evolution, current status, and future prospects. Offshore wind is not just a renewable energy source but also a catalyst for significant positive change, offering benefits like abundant resources, reduced environmental impact, job creation, and enhanced energy security. Technological advancements and supportive policies have made it increasingly competitive, facilitating its integration into mainstream energy systems. Additionally, offshore wind development plays a crucial role in combating climate change, fostering economic growth, and promoting social equity. Examples include regions like Louisiana utilizing their expertise to transition to offshore wind, and international collaborations, such as between India and the EU, showing global momentum towards this clean energy source. Despite challenges like regulatory complexities and ensuring inclusivity, the findings provide a roadmap for navigating these issues and unlocking the full potential of offshore wind for sustainable development. Offshore wind represents not only a solution to energy needs but also a beacon of hope for a sustainable and prosperous future. By leveraging legal innovations, economic opportunities, and policy integration, Nordic countries and beyond can lead the way to a greener, more equitable world. Let's seize this opportunity with determination and vision, ensuring tangible benefits for future generations. Thank you.

3. Countries Studies

1) Denmark:

Despite the existence of various cooperation platforms, cross-border offshore renewable energy (ORE) projects have not become widespread. However, in a recent development, certain member states have begun to convert political pledges into tangible actions. For instance, Denmark and the Netherlands have committed to collaborating on research initiatives aimed at establishing a North Sea Wind Power Hub[1]. The Blue Denmark, part of the Danish economy's Climate Partnerships, aims to reduce greenhouse gas emissions by 70% by 2030 and achieve climate neutrality by 2050. It emphasizes energy efficiency, port improvements, and green fuel adoption, advocating for regulation through the International Maritime Organization (IMO) due to shipping's global nature and competitiveness. The partnership envisions the first ocean-going zero-emission vessel operational by 2030 and stresses

[1] North Sea Wind Power Hub. Retrieved from https://northseawindpowerhub.eu/

the importance of renewable energy production and storage for decarbonizing the shipping sector[1]. The 'Zero-Emission Shipping Mission', led by the Danish Maritime Authority, sets ambitious goals for zero-emission vessel operations and fuel production[2]. It identifies innovation gaps and emphasizes public-private collaboration to achieve these objectives. Danish ports aim to phase out fossil fuels by 2025 and rely entirely on renewable energy by 2030. Offshore energy has significant potential, with plans for 40 GW of production, contributing to Denmark's carbon neutrality goals. Mussel farming faces challenges due to environmental concerns, leading to a halt in new license applications in 2021[3]. Around 5% of the world's wind turbines are offshore, primarily in Europe, with Denmark among the leading countries. The 'Zero-Emission Shipping Mission' targets net-zero emissions by 2050 and significant reductions in greenhouse gas emissions, focusing on ships, fuels, and fueling infrastructure[4]. It identifies innovation gaps and emphasizes public-private collaboration. Additionally, the DecomBlades[5] project aims to commercialize sustainable recycling routes for wind turbine blades, supported by Innovation Fund Denmark.

2) Finland:

The maritime cluster in Finland, including the maritime industry, shipping, and port operations, contributes significantly to the economy, generating over EUR 14 million in 2019 and employing about 50,000 people *(The Maritime Policy Action Plan, 2022)*[6]. The Finnish government prioritizes three areas in its maritime policy: maritime cluster, marine production, and protection of seas. It aims to support digitalization, autonomous transport, and emission reduction in the maritime sector while maintaining competitiveness *(Government Resolution on Finland's Maritime*

[1] DK2030 Et grønnere, sikrere og stærkere Danmark 2030 (2022). Retrieved from (in Danish): https://www.regeringen.dk/media/11683/dk2030-et-groennere-sikrere-og-staerkere-danmark-2030_web.pdf.
Energiateollisuus. (2024). Vesivoima. Retrieved from https://energia.fi/energiatietoa/energiantuotanto/sahkontuotanto/vesivoima/.

[2] Zero-Emission Shipping Mission (2022) Industry Roadmap for Zero-emission Shipping by 2030. Retrieved from: https://mission-innovation.net/wp-content/uploads/2022/04/Zero-Emission-Shipping-Mission-Roadmap-1-1.pdf.

[3] The Danish Government's Climate Partnership (2021) Climate Partnerships for a Greener Future,.Retrieved from: https://issuu.com/stateofgreen/docs/climate-partnerships_web-komprimeret?fr=xKAE9_zJGAA&submissionGuid=2c0aa399-6764-4591-85aa-f5d1e3689b80

[4] North Sea 2050 Spatial Agenda (2014). Dutch Ministry of Infrastructure and Environment. Retrieved from:
https://www.noordzeeloket.nl/publish/pages/122268/north_sea_2050_spatial_agenda_lo_res_3562.pdf.

[5] DecomBlades. (2024). Wind industry blade decommissioning. Retrieved from https://decomblades.dk/.

[6] Maritime Policy Action Plan (2022) Publications of the Finnish Government 2022:44. Retrieved from: https://julkaisut.valtioneuvosto.fi/bitstream/handle/10024/164192/VN_2022_44.pdf?sequence=4&isAllowed=y.

Policy guidelines from the Baltic Sea to the Oceans, 2019)[1]. Likewise, Finland strives to integrate sustainable development fully into the national budget process (Wolff, Teebken & Jacob, 2022). Helsinki Port Ltd. and Turku Port are committed to reducing emissions and promoting sustainable practices. Helsinki Port aims to become carbon neutral by 2035, with specific targets for emission reduction and strategies focusing on alternative fuels and energy efficiency *(World Port Sustainability Program, 2023)*[2]. Turku Port is part of a project to develop a carbon-neutral "green corridor" between Turku and Stockholm by 2027, aligning with Turku's goal to be carbon neutral by 2030 (Åbo Akademi University, 2022; Port of Turku, 2023) [3] [4]. Pori Port, a major cargo port in Finland, plans to expand its operations in sustainable blue economy and carbon neutrality, attracting investments in recycling, bioconversion, and renewable energy projects (Port of Pori, 2023). Finland's offshore wind energy sector is growing, with new projects planned to increase capacity significantly by 2030 *(Finnish Wind Power Association, 2023; Metsähallitus, 2023)*[5]. Hydropower remains an important source of renewable energy in Finland, facing challenges in future development due to environmental concerns *(Energiateollisuus, 2024)*[6]. Marine production, aquaculture, and species cultivation are also prioritized areas, with growing interest and entrepreneurial activity in low-trophic aquaculture *(Prime Minister's Office, 2023)*[7]. The Central Finland Region has a roadmap for carbon neutrality by 2030, focusing on various sectors and evaluating impacts across economic, social, environmental, and climate emission reduction criteria *(Hiilineutraali Keski-Suomi 2030, 2023)*[8]. The assessment highlights the importance of continuous evaluation and adaptation to address challenges and trade-offs in achieving sustainability goals.

[1] Government Resolution on Finland's Maritime Policy Guidelines: From the Baltic Sea to the Oceans (2019) Prime Minister's Office. Retrieved from: http://urn.fi/URN:ISBN:978-952-287-693-5.
[2] World Port Sustainability Program (2023). Port of Helsinki – Carbon Neutral Port 2035. Retrieved from: https://sustainableworldports.org/project/port-of-helsinki-carbon-neutral-port-2035.
[3] Åbo Akademi University. (2022). Carbon-neutral sea route between Stockholm and Turku – Business Finland has granted the project significant funding. Retrieved from https://www.abo.fi/en/news/rmc-viking-line-abo-akademiand-kempower-are-developing-a-carbon-neutral-sea-route-between-stockholm-and-turku-business-finland-hasgranted-the-project-significant-funding/.
[4] Port of Turku. (2023). Turun Satama tähtää hiilineutraalisuuskisassa Euroopan kärkikastiin. Retrieved from: https://aboard.portofturku.fi/2023/12/turun-satama-tahtaa-hiilineutraalisuuskisassa-euroopan-karkikastiin/.
[5] Finnish Wind Power Association (2023) General about offshore wind power. Retrieved from: https://tuulivoimayhdistys.fi/en/wind-power-in-finland-2/offshore-wind-power/general-about-offshore-wind-power.
[6] Energiateollisuus. (2024). Vesivoima. Retrieved from https://energia.fi/energiatietoa/energiantuotanto/sahkontuotanto/vesivoima/.
[7] Government Resolution on Finland's Maritime Policy Guidelines: From the Baltic Sea to the Oceans (2019) Prime Minister's Office. Retrieved from: http://urn.fi/URN:ISBN:978-952-287-693-5.
[8] Hiilineutraali Keski-Suomi 2030, 2023. https://hiilineutraali.keskisuomi.fi/ (Access date: May 2024).

3) Iceland:

Southern Iceland has demonstrated the world-class geothermal potential of oceanic spreading centers, allowing onshore development of submarine geothermal systems. This experience provides a "flying start" for offshore development, allowing for the production of transportable green hydrogen or ammonia (Bolton, Crossley, Fowler, Schwarz-Schampera & Njue, 2024, pp. 1-8). Iceland, despite its abundant wind resources, has historically relied more on geothermal and hydropower. However, recognizing the need for de-carbonization and clean energy, Iceland is now turning its attention to wind power. This shift aligns with the country's ambitious goals for energy independence and sustainability. While only a small percentage of Iceland's energy currently comes from wind (approximately 2%), significant developments are underway. For instance, a massive offshore wind farm project, expected to generate 10 GW of power, is in the works, signaling a substantial increase in wind energy's contribution. Additionally, the government is streamlining regulations to encourage smaller-scale onshore wind projects. Statistics paint a clear picture of Iceland's wind energy landscape: the country has an installed capacity of around 52 MW, contributing to an annual production of approximately 5 TWh. While this represents only a fraction of the total generation capacity, the potential is immense. Studies suggest that Iceland's wind resource potential exceeds 80 TWh/year onshore and over 1,000 TWh/year offshore. However, addressing challenges such as grid infrastructure upgrades and environmental considerations will be crucial for successful wind power expansion. Despite these challenges, Iceland's wind energy journey holds promise. By leveraging its wind resources effectively, the country can advance towards its goal of carbon neutrality by 2040, create new economic opportunities, and contribute to regional clean energy needs[1]. With careful planning and strategic investments, wind power is poised to play a significant role in shaping Iceland's sustainable energy future.

4) Norway:

The Norwegian government has established a goal of identifying regions capable of producing 30 GW of offshore wind energy by 2040. Currently, strategic environmental assessments are underway for fifteen areas earmarked for offshore wind farm development. These areas have the potential to generate between 4600–12,600 MW, with an expected output of 19–50 TWh *(Offshore wind power in Norway Strategic Environmental Assessment, 2013)*. In spring 2023, the Norwegian Water Resources and Energy Directorate introduced 20 additional potential areas for offshore wind development. Strategic impact assessments have commenced for three of these areas, which may be eligible for licensing in the 2025 round, along with

[1] Putra. (2024, February 20). Iceland wind energy projects. Retrieved from https://www.exaputra.com/2024/02/iceland-wind-energy-projects.html.

future licensing rounds *(Ministry of Petroleum and Energy, 2023)* [1]. Moreover, the government is actively involved in enhancing skills and expertise to bolster Norway's international competitiveness. At the national level, efforts are focused on developing and testing zero and low-emission technologies, such as electric ferries and advanced autonomy solutions. Additionally, commercially viable technologies for hydrogen storage and hydrogen-based systems, like ammonia, are being explored as alternatives for long-distance or high-energy vessels *(The Norwegian Government's Hydrogen Strategy, 2020)* [2]. Norway has taken a leadership role in the international 'Zero-Emission Shipping Mission' public-private partnership. The country has also introduced the Environmental Port Index (EPI) to evaluate cruise ship environmental performance while in port, which is set to be implemented in numerous Norwegian ports *(Action Plan for Green Shipping 2019)*[3]. The Norwegian government opened Utsira Nord (UN) and Sørlige Nordsjø II, Phase 1 for offshore wind farm project licensing applications in June 2020. The deadline for pre-qualification applications for SNII was extended to November 15, 2023. An auction for SNII areas was conducted in March 2024, with Ventyr SN II AS winning the bid at 1.15 NOK/kWh (Skalstad Ellensen, 2024). The licensing process for UN has been delayed due to ongoing clarifications with ESA regarding state aid pre-approval. The Offshore Energy Act and its regulation are being amended to ensure a fair process for awarding seabed rights in UN and SNII. Pre-qualification criteria have been expanded and clarified, emphasizing technical competence, financial capacity, and compliance with health, environmental, and safety regulations. The awarding process for UN will be qualitative, focusing on innovation and new technology. Developers are responsible for grid connections, with radial connections planned for the first licensing round. Additional approvals and permits are required for offshore wind projects, including government approval of project plans and acquisition of a trading license to sell power through the Norwegian grid.

5) Sweden:

The maritime sector in Sweden, encompassing shipping, marine technology, ports, and academia, generates an annual turnover of approximately 85 billion SEK and employs around 30,000 people. Collaborative efforts between Swedish waterborne transport companies and research institutions aim to achieve greenhouse gas

[1] Press release. (2023, September 14). Three new offshore wind areas considered for opening and tender in 2025. Retrieved from https://www.regjeringen.no/en/aktuelt/tre-nye-havvindomrade-aktuelle-for-opning-og-utlysing-i-2025/id2993904/.

[2] The Norwegian Government's Hydrogen Strategy towards a Low-emission Society (2020) Norwegian Ministry of Petroleum and Energy Strategy Norwegian Ministry of Climate and Environment. Retrieved from: https://climate-laws.org/document/the-norwegian-governments-hydrogen-strategy_7e5c.

[3] The Action Plan for Green Shipping. (2019, June 20). Retrieved from https://www.regjeringen.no/en/dokumenter/the-governments-action-plan-for-green-shipping/id2660877/.

reduction targets set by the International Maritime Organization, with initiatives like the Lighthouse - Swedish Maritime Competence Centre facilitating cooperation among stakeholders. This collaboration has led to the development and implementation of "new generation" vessels, such as battery-powered ferries and offshore wind farm service vessels, supported by public-private partnerships. Despite Sweden's shipping fleet representing only 1-2% of the Baltic Sea's annual fleet, there's recognition of the international nature of the sector, necessitating cross-border collaboration incentives (Barquet, et al., 2023). *The Swedish Maritime Strategy (2023)*[1] underscores the importance of achieving zero-emission goals throughout the maritime cluster by enhancing sustainability across the entire system. The Port of Gothenburg, a significant maritime hub in Sweden, aims to reduce its CO2 emissions by 70% by 2030. Recent legislation in Finland and Sweden mandates regular reporting to the legislature on policy alignment with Sustainable Development Goals and Nationally Determined Contributions, presenting opportunities to translate climate-SDG discussions into action through streamlined reporting *(Teebken et al., 2021)* (Wolff, Teebken & Jacob, 2022). In the renewable energy sector, Sweden aims to significantly increase offshore wind power production, with goals set to create thousands of jobs by 2030 and 2050. The Swedish Maritime Strategy emphasizes investments in offshore wind and research in wave energy, along with efforts to expand renewable electricity production and mature technologies. Although the Swedish Maritime Strategy does not extensively discuss low-trophic aquaculture development, initiatives like Blue Food focus on sustainable aquaculture research and innovation. Seaweed farming is recognized as a promising industry, supported by favorable legislative frameworks and ongoing national strategies to transition to renewable resources (Hasselström, et al., 2020; Fletcher, 2024; Sweden, 2021).

In the recent discussions held by the Nordic Council Committee for a Sustainable Nordic Region, it was emphasized that urgent cooperation among Nordic countries is necessary to expand offshore wind power effectively. Despite Denmark's expertise in bed-mounted wind power and Norway's focus on technical advancements in floating wind power, progress in offshore wind projects across the region is hindered by prolonged permit processes, technical challenges, and environmental concerns. The committee proposes joint efforts among Nordic governments to address these challenges by sharing knowledge on permit processes, enhancing cooperation in research and development, and strengthening collaboration between national power grid companies (Wendt, 2023).

[1] Swedish Maritime Strategy (2023). Retrieved from https://maritime-spatial-planning.ec.europa.eu/practices/swedish-maritime-strategy and https://centerformaritimestrategy.org/publications/2023-fact-finding-trip-to-sweden/.

4. Challenges and Opportunities

Offshore wind generation in Nordic countries faces several challenges, including environmental impact assessment (EIA) and permitting, grid connection and infrastructure, technological innovation, supply chain localization and industry development, environmental and social acceptance, and weather and operational challenges. EIA processes involve thorough assessments of potential ecological impacts, which can delay project timelines and increase costs. Grid connection and infrastructure are crucial for supporting offshore wind farms, as the remote location of many sites often requires extensive upgrades to connect them to the onshore electricity grid. Technological innovation is needed to reduce costs and improve efficiency, particularly in turbine design, foundation structures, and installation methods. Continued research and development efforts are essential to overcome technical barriers and enhance the competitiveness of offshore wind compared to conventional energy sources. Nordic countries are increasingly focusing on developing local supply chains to support the offshore wind industry, but establishing a robust supply chain requires significant investments in manufacturing capacity and infrastructure. Fostering collaboration among stakeholders and promoting innovation within the domestic industry is essential for building a competitive offshore wind sector. Environmental and social acceptance are also important, as offshore wind projects often face opposition from environmental groups, local communities, and other stakeholders concerned about potential ecological impacts, visual aesthetics, and property values. Balancing renewable energy deployment with environmental conservation is essential for sustainable growth in Nordic countries. Weather and operational challenges pose operational challenges for offshore wind projects, such as severe storms, high winds, icy conditions, and rough seas. Developing robust offshore wind technologies and optimizing operational strategies are critical for ensuring long-term viability. On the other hands, offshore wind generation is a promising avenue for economic growth in Nordic countries, providing employment prospects across various sectors. The industry creates jobs and significantly contributes to the region's economic development. The expansion of offshore wind projects requires a diverse workforce, including engineers, technicians, project managers, and environmental specialists, which reduces unemployment rates and stimulates economic growth. Specialized skills and expertise are required, leading to a growing demand for vocational training programs. Investments in skill development initiatives enhance workforce employability and contribute to overall human capital development. The offshore wind sector relies on a robust supply chain, fostering entrepreneurship and industrial development. The establishment of offshore wind projects attracts significant investments, spurring economic activity, creating ancillary industries, developing infrastructure, and increasing tax revenues for governments. Nordic countries, with their expertise in renewable energy technologies, are well-positioned to capitalize on

the global demand for offshore wind solutions. Leveraging strengths in innovation and engineering, Nordic firms can export products and services to international markets, boosting exports and enhancing competitiveness. Offshore wind generation plays a crucial role in mitigating climate change and reducing reliance on fossil fuels, aligning with Nordic nations' sustainability goals. The offshore wind sector offers long-term economic stability, attracting further investments and fostering confidence in the business environment.

5. Conclusion

As we conclude our discussion on harnessing offshore wind for sustainable economic growth in Nordic countries, it's crucial to acknowledge the inevitable impact of renewable energy initiatives on the environment. However, in our pursuit of clean electricity generation, we are steadfast in our commitment to strike a balance between environmental preservation and energy production. We are dedicated to undertaking all necessary measures to minimize the environmental footprint of offshore wind farms. In instances where environmental impact is unavoidable, we pledge to implement compensatory measures aimed at enhancing the overall state of the environment. Furthermore, there is significant potential to reduce the operational costs per kilowatt of energy produced in offshore wind farms through the development of more advanced ocean observations. As noted by Jake Kritzer, executive director of the Northeastern Regional Association of Coastal Ocean Observing Systems, this advancement holds promise for optimizing offshore wind energy production. Moreover, the European Union's offshore renewable energy strategy sets ambitious targets for 2030 and 2050. While there is support from the Commission and member states, challenges persist in achieving social and environmental sustainability. Despite the aid of maritime spatial planning in sea space allocation, conflicts endure, socioeconomic impacts remain underexplored, and environmental considerations are sometimes overlooked[1]. It's important to recognize that energy is the main contributor to global greenhouse gas emissions, and regions like Iceland, Norway, Canada, and the United States are among the largest per capita energy consumers, each exceeding 50,000 kWh annually (British Petroleum (BP), 2022)[2]. Addressing these challenges requires continued collaboration, innovation, and integration of policies aimed at achieving sustainable

[1] European Court of Auditors. (2023, September 18). Special report 22/2023: Offshore renewable energy in the EU – Ambitious plans for growth but sustainability remains a challenge. Retrieved from https://www.eca.europa.eu/en/publications?ref=SR-2023-22.

[2] British Petroleum (bp). (2022). Statistical Review of World Energy. Retrieved from: https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html.

energy production while mitigating environmental impacts.

6. Summary of Key Findings

The establishment of the Global Offshore Wind Alliance (GOWA), led by Denmark, IRENA, and GWEC, signifies a concerted effort to promote offshore wind adoption globally by garnering political support and sharing knowledge within a global community of practice, including supply chains. Additionally, GWEC's initiative (Hurtado Sandoval, 2015) to develop a global ESG/sustainability framework for the wind supply chain underscores the importance of environmental, social, and governance considerations in offshore wind development. Furthermore, the decline in annual wind installations in Europe, attributed to lower installations in countries like Finland, Spain, Turkey, and Sweden, highlights the need for strategic interventions to bolster wind energy deployment. Proposed strategies include improving vessel energy efficiency, promoting fuel flexibility, and advocating for regulatory reform. Moreover, port development strategies are deemed crucial for decarbonizing port operations and providing clean services, although challenges such as material recycling and circular resource use need to be addressed to ensure sustainable energy production. Additionally, the hurdles faced by low trophic aquaculture in the Baltic region, stemming from environmental conditions and regulatory barriers, underscore the necessity of streamlined regulations to support its development. Overall, these findings emphasize the importance of collaborative efforts, innovative strategies, and policy integration in harnessing offshore wind for sustainable economic growth in Nordic countries and beyond.

Q1: What are the existing legal frameworks governing offshore wind development in Nordic countries, and how do they impact sustainable economic growth?

R: The legal frameworks governing offshore wind development in Nordic countries play a crucial role in shaping sustainable economic growth. These frameworks typically encompass a range of regulations, policies, and licensing procedures that govern the planning, construction, and operation of offshore wind projects. In Nordic countries like Denmark, Norway, Sweden, Finland, and Iceland, offshore wind development is guided by a combination of national legislation and international agreements. These legal frameworks aim to balance the promotion of renewable energy sources, such as offshore wind, with environmental protection, indigenous rights, and economic development. One key aspect of these legal frameworks is the permitting and licensing process for offshore wind projects. Governments in Nordic countries typically require developers to obtain permits and undergo rigorous environmental impact assessments before commencing offshore wind development. These assessments evaluate the potential environmental, social, and economic

impacts of proposed projects and help ensure that developments are conducted in a sustainable manner. Additionally, legal frameworks often include provisions for community engagement, indigenous consultation, and stakeholder involvement. This ensures that local communities, including indigenous groups, have a voice in the decision-making process and can contribute to the planning and development of offshore wind projects. By fostering transparent and inclusive processes, legal frameworks help build trust and support for offshore wind development, thereby contributing to sustainable economic growth. Furthermore, legal frameworks may include incentives and support mechanisms to encourage investment in offshore wind projects. These may take the form of feed-in tariffs, tax incentives, or financial support for research and development. By providing a favorable regulatory environment and financial incentives, governments can attract investment, create jobs, and stimulate economic activity in the offshore wind sector. Overall, the existing legal frameworks governing offshore wind development in Nordic countries play a critical role in promoting sustainable economic growth. By balancing the interests of various stakeholders, protecting the environment, and providing incentives for investment, these frameworks support the responsible development of offshore wind resources while contributing to the transition to a low-carbon economy.

Q2: How do economic opportunities from offshore wind energy differ among Nordic countries, and what factors contribute to these variances?

R: The economic opportunities from offshore wind energy vary significantly among Nordic countries due to a combination of factors. Firstly, geographic differences, such as varying wind resources and offshore conditions, impact the feasibility and potential scale of offshore wind projects in each country. Additionally, differences in regulatory frameworks, including permitting processes, environmental regulations, and financial incentives, influence the ease of project development and attractiveness to investors. Technological capabilities and innovation infrastructure also play a crucial role, with countries like Denmark and Norway leveraging their expertise to drive down costs and develop cutting-edge offshore wind technologies. Furthermore, market conditions, including energy prices, demand forecasts, and market integration, affect the economic viability and competitiveness of offshore wind projects across the region. Understanding these factors is essential for maximizing the economic potential of offshore wind energy while promoting sustainable growth in the Nordic countries.

Q3: What innovative legal strategies have Nordic countries adopted to address regulatory barriers and advance offshore wind development?

R: Nordic countries have adopted a range of innovative legal strategies to address regulatory barriers and advance offshore wind development, reflecting their commitment to sustainable energy transition and economic growth. These strategies

include streamlining permitting processes to facilitate project approvals, establishing clear regulatory frameworks that provide certainty for investors, implementing supportive policies such as feed-in tariffs or competitive auctions to incentivize renewable energy investment, and fostering collaboration between government, industry, and local communities to ensure stakeholder engagement and social acceptance. Additionally, some countries have introduced specific legislation or zoning plans to designate areas for offshore wind development, promote grid integration, and mitigate potential conflicts with other marine uses. Moreover, Nordic countries have been proactive in aligning their legal frameworks with international standards and best practices, leveraging partnerships with regional and global organizations to exchange knowledge, harmonize regulations, and promote cross-border cooperation in offshore wind governance. These innovative legal strategies not only address regulatory barriers but also create an enabling environment for offshore wind projects, unlocking their economic, environmental, and social benefits for the region..

Q4: How does the integration of policies at national and regional levels affect the potential for sustainable economic growth through offshore wind energy in the Nordic region?

R: The integration of policies at national and regional levels plays a crucial role in shaping the potential for sustainable economic growth through offshore wind energy in the Nordic region. Alignment and coordination of policies related to energy, environment, industry, innovation, and regional development can create a conducive regulatory environment that fosters investment, innovation, and collaboration across the offshore wind value chain. By harmonizing permitting procedures, establishing supportive financial incentives, and promoting cross-border cooperation, integrated policies can streamline project development, reduce administrative barriers, and enhance investor confidence. Moreover, cohesive policy frameworks can facilitate the deployment of offshore wind projects at scale, optimize grid integration, and promote the development of complementary infrastructure and industries, such as port facilities, manufacturing hubs, and research centers. This holistic approach not only drives economic growth and job creation but also contributes to environmental sustainability, energy security, and climate resilience, positioning the Nordic region as a global leader in offshore wind innovation and deployment.

Q5: How can the Nordic countries strategically leverage offshore wind energy to achieve sustainable economic growth while effectively integrating legal innovate`ons, addressing environmental goals, and advancing the objectives outlined in Sustainable Development Goal 7 (SDG 7) and other relevant environmental targets?

R: To strategically leverage offshore wind energy for sustainable economic growth in the Nordic countries, a holistic approach is needed that integrates legal

innovations, environmental goals, and the objectives outlined in Sustainable Development Goal 7 (SDG 7) and other relevant environmental targets. This entails developing supportive regulatory frameworks that streamline permitting processes, incentivize investment, and ensure environmental sustainability through rigorous impact assessments and mitigation measures. Moreover, fostering collaboration between government, industry, academia, and local communities is essential to promote transparency, stakeholder engagement, and social acceptance of offshore wind projects. Investments in research and development to advance offshore wind technology and infrastructure, including grid integration and energy storage, can enhance the competitiveness and reliability of offshore wind energy while contributing to job creation and industrial growth. Additionally, prioritizing the development of offshore wind projects in areas with high wind resource potential, minimal environmental impact, and strategic grid connections can optimize energy production and maximize economic benefits. By aligning offshore wind development strategies with SDG 7 targets, such as ensuring universal access to affordable, reliable, and modern energy services, Nordic countries can play a leading role in transitioning to a sustainable energy future while fostering economic prosperity and environmental stewardship.

7. Policy Implications

Policy implications for harnessing offshore wind for sustainable economic growth in Nordic countries are multifaceted and crucial for realizing the full potential of this renewable energy source. First and foremost, there is a need for comprehensive and harmonized legal frameworks that facilitate offshore wind development while ensuring environmental protection and indigenous rights. Legal innovations should aim to streamline permitting processes, provide clarity on property rights and seabed leasing, and establish mechanisms for stakeholder engagement and dispute resolution. Moreover, policymakers must prioritize economic incentives and regulatory mechanisms that attract investment, promote innovation, and drive down the costs of offshore wind projects. This includes implementing financial support mechanisms such as feed-in tariffs, renewable energy certificates, and tax incentives, as well as fostering public-private partnerships and research collaborations to advance technological advancements. Additionally, policy integration with broader sustainable development goals (SDGs) is essential to ensure that offshore wind projects contribute to social equity, environmental sustainability, and economic prosperity in Nordic communities. This requires aligning offshore wind policies with national and regional energy strategies, climate action plans, and maritime spatial planning initiatives to optimize resource allocation, minimize conflicts, and maximize synergies with other sectors. Overall, a holistic approach to policy development and implementation is paramount for harnessing offshore wind as a

catalyst for sustainable economic growth in Nordic countries, while advancing towards a low-carbon, resilient, and inclusive energy future.

8. Recommendations

a) The need for a coordinated approach

Offshore wind development requires a coordinated approach involving public and private institutions to reduce costs and build a sustainable energy system. This can lead to job creation, investment attraction, and reduced dependence on imported energy sources. Investment in research and development, infrastructure, and Nordic-focused think tanks can foster investment in the offshore wind sector. Setting ambitious targets and creating policies to incentivize the industry are crucial steps. Governments can aim to generate a specific percentage of energy from offshore wind power or create market mechanisms like feed-in tariffs. Streamlining regulatory processes and providing financial incentives can also help. Encouraging collaboration among industry stakeholders can drive innovation, facilitate knowledge-sharing, and reduce costs. This coordinated approach ensures the successful development of offshore wind energy in Nordic states, bringing both economic and environmental benefits to the region.

b) Unified Action for Offshore Wind Power Expansion

The Nordic Council Committee for a Sustainable Nordic Region is calling for coordinated efforts among Nordic countries to expand offshore wind power. The committee emphasizes the importance of sharing experiences and knowledge during the transition from fossil-based to renewable energy systems (Damsgaard, 2023). Despite Denmark excelling in bed-mounted wind power, Norway focuses on technical advancements in floating wind power. Despite widespread interest, progress is hindered by prolonged permit processes, technical hurdles, and environmental concerns. The committee proposes joint efforts among Nordic governments to address these challenges. It advocates for knowledge sharing on permit processes, increased cooperation in research, development, and innovation among Nordic institutions, and strengthening collaboration between national power grid companies and integrating Nordic electricity networks. Norwegian parliamentarian Lene Westgaard-Halle emphasizes the potential of renewable energy and the importance of cross-country collaboration and interconnectors for success. The committee's proposal is supported by Swedish MP Emma Berginger and Norwegian parliamentarian Lene Westgaard-Halle.

c) Green Recovery

To facilitate the accelerated deployment of renewable and the electrification of various sectors, such as transportation, heating, cooling, and industry, it is imperative

to introduce meaningful carbon pricing on an international scale, ensuring fairness across energy sources. Moreover, efforts should be directed towards ensuring adequate investment in critical infrastructure, including power systems and grid infrastructure, while adhering to sustainability standards and accessing low-cost finance. Strong support for innovation and research and development (R&D) programs is essential to expedite the deployment of the next generation of wind turbine platforms. Additionally, investment schemes for both public and private entities should be built upon the principle of "No Harm" to society and the environment, incorporating clear criteria for sustainability. Evidence-based decision-making, guided by metrics such as GDP impact, environmental considerations, resource depletion, social value, and system resilience, should inform government-backed investments. Furthermore, there is a need to enforce reporting requirements for sustainability and climate-related disclosures within institutional and multilateral lending and relief funds, aligning with the recommendations of the Task Force on Climate-related Financial Disclosures (TCFD). Lastly, swift action is required to scale up green financing for emerging markets and developing economies, which are experiencing accelerated capital flight and mounting debt that hinder their transition to clean energy.

9. Future Directions for Research

The Nordic countries are increasingly utilizing offshore wind for sustainable economic growth, but there are several challenges and opportunities to be addressed. First, a thorough analysis of the legal frameworks governing offshore wind development is needed to identify best practices and areas for improvement. This will help policymakers and industry stakeholders understand the barriers to offshore wind deployment and promote sustainable practices. Second, the economic opportunities and challenges specific to each country should be explored, considering factors like resource potential, market dynamics, technological innovation, and investment incentives. The socio-economic impacts of offshore wind projects, such as job creation and regional economic growth, will provide valuable insights into the broader implications for sustainable development and energy transition. Third, the integration of offshore wind development with broader policy objectives, such as the United Nations Sustainable Development Goals and climate targets, should be explored. This will help identify synergies and trade-offs, as well as opportunities for policy coherence and integration across sectors. Fourth, interdisciplinary research should consider the environmental, social, and governance (ESG) dimensions of offshore wind projects, including their impact on marine ecosystems, coastal communities, and indigenous rights. Finally, research should explore emerging trends and innovations in offshore wind technology, such as floating offshore wind, digitalization, and grid integration.

10. Author's Contributions

Junaid Sattar Butt, corresponding author, played a pivotal role in conceptualizing the research, designing the methodology, and synthesizing the findings. His background in law, coupled with his practice experience in Law provides valuable insights into the legal innovations and policy implications concerning offshore wind energy. Furthermore, his contribution extended to drafting and revising the manuscript, ensuring clarity and coherence in presenting the research findings. Junaid Sattar Butt's dedication to this project is evident through his proactive communication and leadership as the corresponding author.

Farzana Kousar, co-author, contributed her expertise in environmental sustainability and policy integration. Her role in the research involved conducting literature reviews, data analysis, and interpreting the results within the context of sustainable development goals (SDGs). With her background in environmental sciences, the co-author provide critical insights into the economic opportunities and environmental implications of offshore wind energy in Nordic countries. Her contributions enriched the discussion on policy integration and the alignment of offshore wind initiatives with broader sustainability objectives.

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