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Akita, Japan: A Model of Sustainable Energy Infrastructure

Japan is one of the oldest countries in the world, with civilizations dating back to 660 BCE. Neolithic people first inhabited the area and became a rice-loving culture during the Yayoi Period, from 300 BCE to 250 CE. Rice cultivation became a staple of culture, religion, and wealth throughout ancient Japan and shaped the country's course of development. Additionally, Japan was never formally colonized and was the colonizer itself. Physical distance from colonial powers, military strength, and lack of profitable resources deterred Western colonizers from the island country. However, Western architecture, city design, and tradition influenced Japan, which can be seen throughout the country today. The ancient Chinese city grid system, Jō-Bō, was adapted by Japan's ancient capital of Heijō-Kyō. The streets were divided around a central axis which separated the city into the Sakyō (East) and Ukyō (West), and additional matrices were created by jō (rows) and bō (columns). The system also designated land parcels by number and modified city layouts based on land management. Conscious developments were made around rice paddies and utilized the natural environment, such as waterways, to maximize crop yields.

Akita "autumn rice fields" Prefecture in Northern Japan is historically known for its rice production. Abundant rice paddies in Akita prefecture led to high population density and intensified labor needs. Increasing populations accelerated the demand for food and energy, and the transition to industrialization began. During the Meiji restoration period starting in 1868, manufacturing plants were built on waterfront areas to increase rice production and accommodate higher populations in Akita Prefecture. The Prefecture followed Jō-Bō city design, but the ancient structures did not account for modern city density; Akita prefecture became

energy poor in attempting to supply the grid with power for both civilians *and* industry. Insufficient energy became a prominent issue across Japan which led the country to import from other countries.

Today, Japan's energy consumption relies heavily on fossil fuels, which has negatively impacted the health, economic, societal, and environmental sectors. For Japan to meet global clean energy requirements, increase local power, source alternatives to nuclear power, and accommodate for land constraints, the country has begun investments in offshore, floating wind farms. The Akita prefecture contains two offshore sites currently under development to regenerate the Japanese power grid and test the energy-yielding potential of new technology and stands as a global experiment for large-scale wind farms as a primary energy source. The results from Akita's Noshiro and Akita ports will become a leading study for floating wind-farm development globally, and investors are hopeful the technology will revolutionize the energy sector.

Energy independence is a critical factor for any industrialized economy and currently, Japan can only rely on itself for 6% of its energy needs. The Middle East and Russia export 94% of the crude oil and natural gas supplying the Japanese power grid, which provides Japan with less economic control and stability in the energy sector. The need for imported energy has remained necessary due to several factors: dense populations, small land area, little to no fossil fuels on land or in nearby waters, structure requirements due to earthquakes, and fear of nuclear energy. The inability to produce energy and build infrastructure for clean energy has led Japan to become the world's sixth-largest greenhouse gas emitter. In the fiscal year of 2019 alone, Japan emitted 1,212 million tonnes of carbon dioxide. The global implications of a small country like Japan emitting large amounts of gases into the atmosphere are catastrophic and visible by

extreme weather patterns, food shortages, increased natural disasters, and decreased public health. In Japan, these effects have led to increased temperature and rainfall, immature crop growth, coral bleaching in nearby reefs, and increased spread of Dengue Fever by Tiger mosquitoes. The imminent and increasing dangers of climate change were addressed in Japanese policy in the COP21 Paris agreement in 2015, where Japan committed to net-zero emissions by 2050. Due to the limiting factors restricting the production of clean energy on-land in Japan, offshore wind farms and WindFloat technology are being implemented, beginning in the Akita Prefecture.

Akita Prefecture suffers from inconsistent crop growth, extreme weather events like Typhoons, and overall economic loss due to extreme climatic damages. However, the geographic area provides a promising landscape for the future of wind energy. The coastal location benefits from consistent wind speeds and natural bays of suitable water depth and substrate. The Noshiro Port and Akita Port off of the Akita Prefecture will be the first large-scale and commercial-basis offshore wind power project in Japan and have piqued interest in financers looking to support promising WindFloat innovation projects.

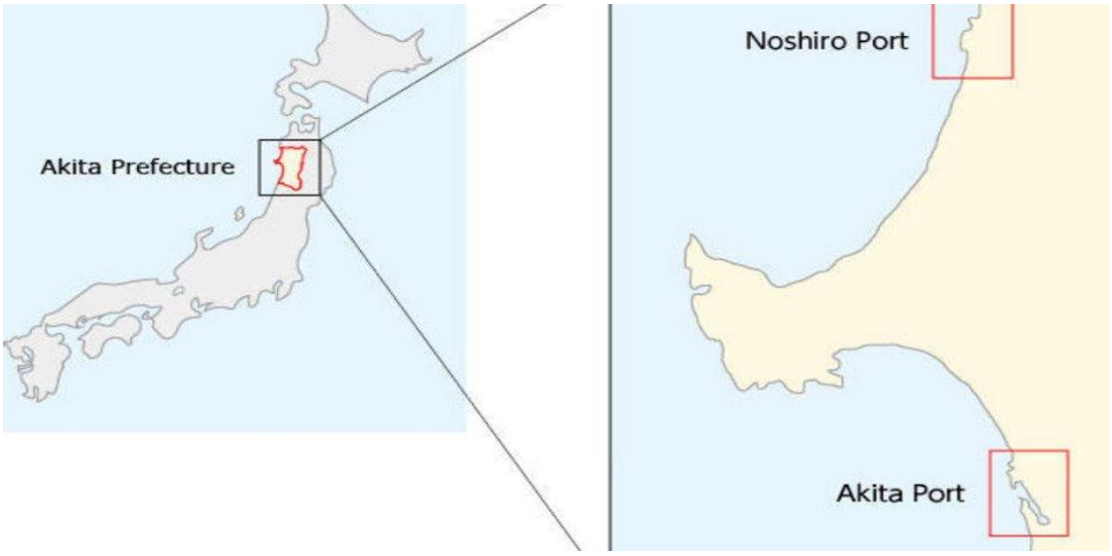

Fig 1. Noshiro and Akita Wind Farm Sites in Northern Japan's Akita Prefecture.

WindFloat technology was engineered by Henrik Stiesdal, a Danish inventor and CEO of Stiesdal climate technology company. Stiesdal designed the "TetraSpar" which differs in modularity and factory-oriented design compared to traditional floating prototypes. The TetraSpar technology can be utilized in Japan's natural conditions and will improve the efficiency of the supply chain closer to project sites. The two sites in Akita Prefecture have also passed rigorous Environmental Impact Assessments over the past decade to ensure the safety and stability of their construction, which will allow the ports to become global pioneers in large-scale WindFloat innovations before competitors. The projects currently have $1B in investments, and the Akita Offshore Wind Corporation (AOW) has executed loan agreements with several lenders.

To further ensure financial security in these projects, the Tohoku Electric Power company in Northern Japan co-sponsored the sites under a twenty-year feed-in tariff program. The Power Purchase Agreement (PPA) between AOW and Tohoku Electric guarantees a fixed electricity rate between the two parties and will accelerate investments in AOW at above-market value. The agreement also provides financial certainty to both parties and reduces barriers in creating and updating facilities.

The attraction to WindFloat technology over traditional, fixed turbines for the Akita Sites is due to the operational stability of the design. The floating turbines can operate in substantially deeper water than fixed turbines, are less susceptible to damage from seismic activity, and can be assembled onshore. The stability, fabrication, and mooring systems are also highly rated against traditional turbines and mostly inexpensive. The revolutionary design of WindFloat farms in Akita prefecture is estimated to supply power to 130,000 homes. The International Energy Agency also estimates the addition of future sites across the Japanese coast will supply the country with enough technical power to satisfy nine times its power needs. The benefits of

offshore wind will spark dramatic improvements throughout Japan including decreasing reliance on other countries, improving energy yield, and meeting their 2050 climate goals.

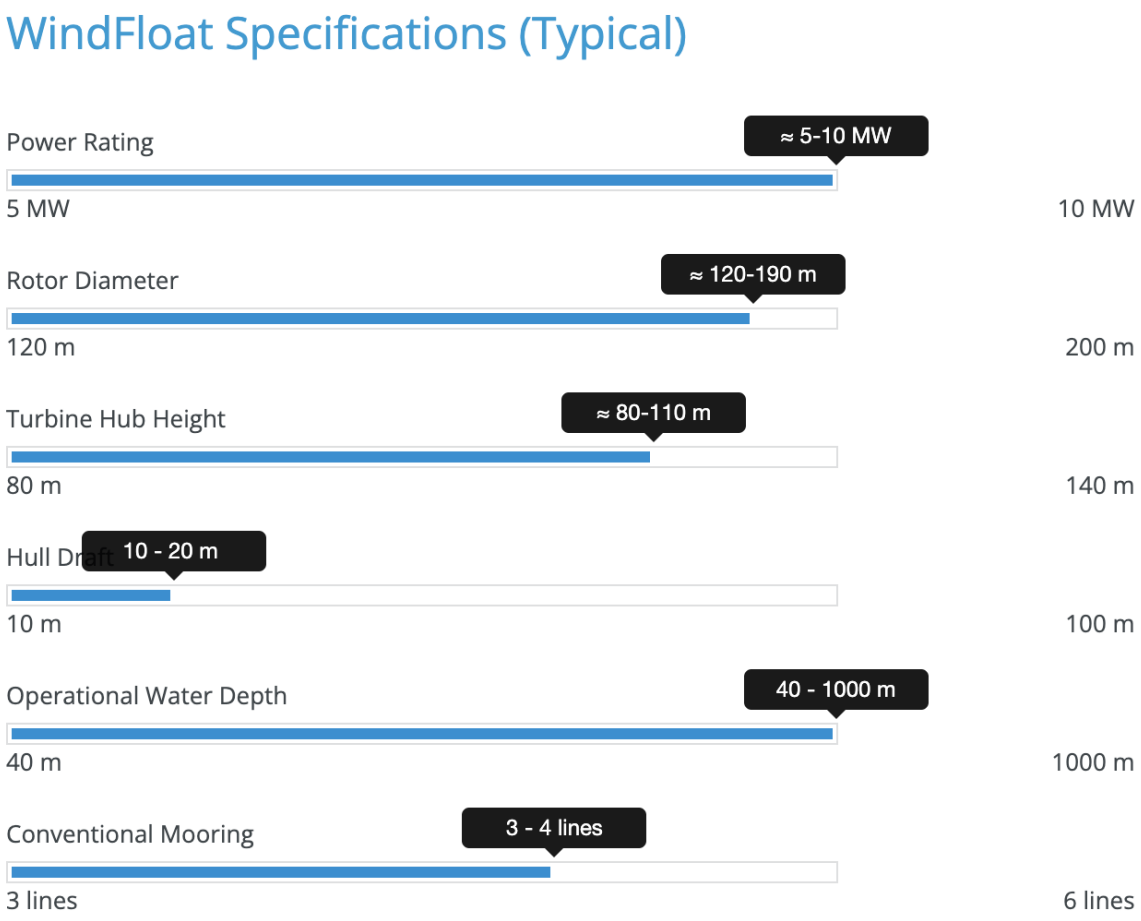

Fig 2. WindFloat specifications and power ranking. *Quality scale improves from left to right.*

The United States shares similar goals and power grid issues to Japan and could benefit from utilizing WindFloat technology. American power lines are well past their lifetime leaving thousands of people without power on an annual basis. The frequency of power outages continues to increase due to amplified climate disasters, poor city planning, and other isolated

accidents. For the United States to meet the 2050 climate goal of net-zero emissions the use of oil and natural gas to supply the power grid will be virtually impossible and will only intensify the effects of global warming. The U.S. Department of Energy (DOE) calls attention to sustainable energy investments and deems offshore floating wind farms the "future of clean energy." Floating wind farms are incredibly attractive and viable on the U.S. coastline as 80% of Americans live within two hundred miles of the coast and hold the highest energy demand. The sites also promise stable generation, large energy potential, jobs, and economic benefits, and set electricity prices. The need for energy in the U.S. is at an all-time high and will continue to peak by 40-60% before 2050, which makes WindFloat engineering a suitable and obtainable solution for Americans.

The large-scale Akita Prefecture operations will be a leading case study for Japanese, American, and global innovation. The Akita and Noshiro ports also offer the world's first insight into complete, or nearly complete, reliance on wind energy by a country and offer a chance to revolutionize the energy sector. Through this assignment, I learned how large the WindFloat sector of offshore wind is becoming and how Japan is projected to be ahead of an arms race for sustainable energy innovation. The solution of using ocean space to accommodate poor land-area could benefit regions across the world, including Pacific island countries. The impact floating wind farms could have on Japan alone is remarkable and could not only help them meet climate goals but could foster more independence and local energy trade. I'm excited to see how the Akita Prefecture sites influence the global market and sustainable design in the United States. It will certainly be an interesting project to monitor, and I foresee a new market of engineers and scientists rising from the innovative initiatives beginning in Japan.

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