Research proposes a self-powered movable seawall for tsunami protection and emergency power generation

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With over 2,780 fishing ports and 993 commercial and industrial ports, Japan faces the challenge of safeguarding these important coastal assets

from the destructive forces of tsunamis. A promising solution lies in the form of a movable barrier system, where gates rising from the seafloor act as barriers, protecting ports against tsunamis, storm surges and high waves. However, during natural disasters, power outages may disrupt the electricity needed to operate the gate.

To address this, researchers led by Professor Hiroshi Takagi from Tokyo Institute of Technology have proposed a self-powered movable seawall system (SMS) that uses microtidal energy to operate the gates. The proposed system, whose details have been published in the journal *Renewable Energy*, consists of gates placed at the port entrance designed to close during periods of port inactivity such as nighttime or holiday seasons. When raised, the differences in water levels between the inside and outside of the port are used to generate electricity, which is then stored and utilized for subsequent gate operations.

"To our knowledge, there is yet no system in the world that uses movable seawalls to generate electricity and then uses that electricity to operate the system itself. In this sense, SMS is a completely new concept," says Prof. Takagi.

Despite Japan's extensive coastline, the tidal ranges—representing the height difference between high and low tides—are considered too small for large-scale tidal power generation. In contrast, the SMS system harnesses microtidal amplitudes in the sea level, which ranges from 10 cm to 150 cm during spring tides.

The system consists of a series of gates with a 30 cm gap that aims to operate the adjacent gates smoothly without interaction and small turbines for power generation housed within the gap. Turbines, with one propeller per 50 cm interval vertically, are placed in the gaps between the gates.

The researchers tested the system's feasibility in Japanese ports, where it operates for eight hours a day, to determine whether it could generate enough electricity to restore the gates under the seafloor after the tsunami alert was lifted, considering the buoyant force of a floating gate. Out of 56 assessed ports across Japan, nine locations were highly feasible, 14 feasible, and 33 unfeasible due to the small potential of energy generation.

However, 20 feasible locations were identified along Japan's western coast, facing the Nankai Trough—a subduction zone known as the source of megathrust earthquakes that occur every century or two. These seismic events have the potential to trigger tsunamis, making the proposed SMS system a promising protective measure for vulnerable ports and their hinterlands.

Furthermore, the researchers identified specific ports, including Himeji and Fukuyama, as examples of favorable locations for generating surplus energy to be stored for later use. These areas, located in the Seto Inland Sea, serve as major industrial hubs with steel industries, shipbuilding, chemical plants, and various factories.

Apart from protecting these critical infrastructures against tsunamis, the proposed system can also provide emergency power to enhance the resilience of these industries in the face of disasters. It integrates disaster prevention with the utilization of renewable energy.

"Our findings outline a synergistic system between disaster prevention and the use of renewable energy," says Prof. Takagi.

While acknowledging challenges such as technical hurdles and restrictions by related laws and regulations, the researchers envision the SMS system as a global safeguard for ports against natural disasters, rising sea levels, and extreme weather, including coastal floods.

Prof. Takagi concludes, "If the technology of the proposed movable tsunami barrier, under the harsh disaster conditions in Japan, can be firmly established through this research, there is no doubt that a day will come when this technology can be exported and deployed overseas as a groundbreaking disaster prevention technology."

More information: Hiroshi Takagi et al, Feasibility of a self-powered movable seawall using microtidal energy in Japan, *Renewable Energy* (2023). DOI: 10.1016/j.renene.2023.119563

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