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Ram, G.[a] , Saad, M.R.[a] , Md Naiem, M.A.[b] , Abidin, N.Z.[b] , Imai, Y.[c] , Ramli, M.Z.[d] , Abdul Rahman, M.R.[a]

Numerical study on the balance of energy of a floating oscillating water column wave energy converter and breakwater hybrid system

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[a] Department of Mechanical Engineering, Faculty of Engineering, Universiti Pertahanan Nasional Malaysia, Kem Sg. Besi, Kuala Lumpur, 57000, Malaysia
[b] Department of Science and Maritime Technology, Faculty of Defence Science and Technology, Universiti Pertahanan Nasional Malaysia, Kem Sg. Besi, Kuala Lumpur, 57000, Malaysia
[c] Institute of Ocean Energy, Saga University, Japan
[d] Institute of Oceanography and Maritime Studies (INOCEM), Kulliyah of Science, International Islamic University Malaysia, Pahang, Kuantan, 25200, Malaysia

Abstract
The conversion of ocean wave energy into useful electrical energy has garnered attention in recent years, mainly due to the global initiative to transition towards clean and renewable energy. Among the various types of wave energy converters, the bottom-detached oscillating water column (OWC) is of particular interest, due to its ability to be installed in the vast near-shore and offshore regions of the ocean. Several studies have looked into the bottom-detached OWC. A fraction of these studies focus on the inclusion of an independent breakwater to improve the performance of the OWC. The aim of this study is to numerically investigate the hydrodynamic performance of a bottom-detached OWC and breakwater hybrid system using an energy balance approach, that is based on the conservation of energy principle. Hydrodynamic coefficients, vorticity magnitudes and a formulated and proposed energy balance equation were calculated and results were analysed. Numerical simulation was conducted using computational fluid dynamics solver ANSYS Fluent, whereby the numerical model was divided into two OWC motion types, four cases of gap lengths and six cases of incident wave frequency. Results show that the proposed energy balance equation accurately interprets the results of OWC-breakwater hybrid system. Fixed OWC shows a significantly higher efficiency than floating OWC case, as do wider gaps 0.07 m and 0.09 m and frequency 5 rad/s. Cases with high extraction energy percentage also show high energy loss. Major sources of energy loss are identified to be heave movement of OWC and vortex formation in OWC. © 2025 Elsevier Ltd

Author Keywords
Breakwater; Energy balance; Hydrodynamic performance; Numerical wave tank; Oscillating water column; Vorticity; Wave energy converter

Index Keywords
Energy dissipation, Floating breakwaters, Vortex flow, Wave energy conversion; Balance of energies, Energy, Energy balance equations, Floating oscillating water columns, Hydrodynamics performance, Numerical wave tank, Ocean-wave energy, Oscillating water column, Wave energy converters, Wave tank; Water waves; breakwater, energy balance, heave, hydrodynamics, numerical model, ocean wave, vorticity, water column, wave energy

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Correspondence Address
Ram G.; Department of Mechanical Engineering, Kem Sg. Besi, Malaysia; email: ramamethyst@gmail.com
Abdul Rahman M.R.; Department of Mechanical Engineering, Kem Sg. Besi, Malaysia; email: rosdzimin@gmail.com

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