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Quantifying wave power and wave energy converter array production potential

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ABSTRACT

Global wave energy inventories show that the West Coast of Canada possesses one of the most energetic wave climates in the world, with an annual wave energy flux of 40–50 kW/m at the continental shelf. With this wave climate there is an opportunity to generate significant quantities of electricity through wave energy conversion (WEC) technologies. However, detailed knowledge of both the temporal and spatial distribution of both wave climate and energy production characteristics are missing precursors to the development of this regional wave energy opportunity.

To quantify the gross wave energy resource along the West Coast of Vancouver Island, and hence the feasibility of deploying WEC technologies, a detailed Simulating WAves Nearshore (SWAN) numerical wave propagation model was developed. The SWAN model encompasses 410,000 km^2, covers 1500 km of the Western Canadian coastline and the resolution is optimised by water depth and proximity to areas of high wave energy flux. The SWAN model hindcasts wave conditions for the 10 year period, at a 3 h temporal resolution. Independent validation of the SWAN model indicates a 0.92 correlation coefficient for significant wave heights and 0.80 for average wave periods.

To translate the gross resource data into electricity generation estimates, novel methods to reveal high priority WEC farm deployment locations were implemented. Using generic WEC performance metrics, theoretical wave farm outputs were synthesized over a decade long time scale. Regional WEC farms were shown

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Notation: The following symbols and abbreviations are used in this paper

B	bias
d	directionality coefficient
E_{rms}	root mean square error
f_i	bin centre frequency corresponding to the ith frequency band (Hz)
g	acceleration due to gravity (m/s^2)
J	omnidirectional wave energy flux (kW/m)
J_θ	directionally resolved wave energy flux (kW/m)
γ	JONSWAP peak-enhancement factor
ρ	seawater density (kg/m^3)
θ	wave direction for ith frequency band (degrees)
ϵ_0	spectral width
H_{mo}	significant wave height (m)
m_n	nth wave spectral moment
r	correlation
S_i	variance density in the ith frequency band (m^2/Hz)
T_e	energy period (s)
T_p	peak period (s)
T_{avg}	average period (s)
WEC	wave energy converter
WCWI	West Coast Wave Initiative
ECMWF	European Centre for Medium Range Weather Forecasts
COAMPS	Coupled Ocean Atmosphere Mesoscale Prediction System
CFSR	Climate Forecast System Reanalysis
NARR	North American Regional Reanalysis
GFS	Global Forecast System
NCEP	National Centres for Environmental Prediction

capable to providing up to 139.92 GWh of energy to the electrical grid annually. The seasonality of the WEC generated electricity correlates well with the load demand within the region.

This updated understanding of the wave climate and wave power production opportunity in Western Canada provides the necessary data to electrical utilities and policy makers to assess the opportunity benefits and costs associated with future WEC industry in Canada.

1. Introduction and objectives

Global wave energy inventories have shown that the West Coast of Canada possesses one of the most energetic wave climates in the world, with average annual wave energy flux of 40–50 kW/m occurring at the continental shelf [1–5]. With this energetic climate there is an opportunity to generate significant quantities of electricity from renewable sources through the use of wave energy conversion (WEC) technologies. Despite a large natural resource, progress within the wave energy conversion industry in Canada has been slow. Strategic development of wave energy projects have

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