

Network Integration of an Array of Wave Energy Converters

Anup Nambiar, Robin Wallace

Work stream 7: Advanced Control and Network Interaction

Introduction

The unpredictable and random nature of the wave energy resource causes voltage fluctuations when wave energy converters (WECs) are connected to the electricity networks. The power quality problem is compounded by the weak, rural grids to which most WEC farms will be connected.

Objectives

- To explore the effects of increased device numbers, array size and physical positioning of the WECs in an array;
- To demonstrate the overall effects of storage on real power production;
- To study the effects of imaginary power control on network voltage profile.

Methodology

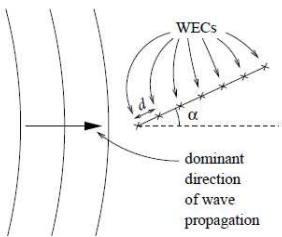


Fig 1. Linear array of WECs oriented with respect to the dominant wave direction

The following simulations were run to identify possible power smoothing strategies:

- Varying energy storage (accumulator) capacity;
- WEC spacing ' $d = 0.25 \lambda_{pk}$, $0.375 \lambda_{pk}$ and $0.5 \lambda_{pk}$ ', where λ_{pk} is the peak wavelength of the spectrum;
- Array orientation ' $\alpha = 0, 30, 60, 90$ degrees;
- Arrays with 4, 6 and 8 WECs;
- Varying DFIG excitation.

Results

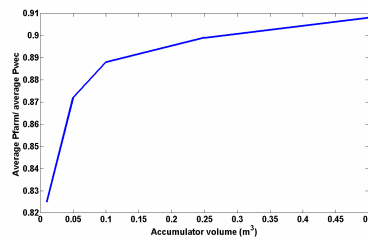


Fig 2. Average power output for varying accumulator capacities

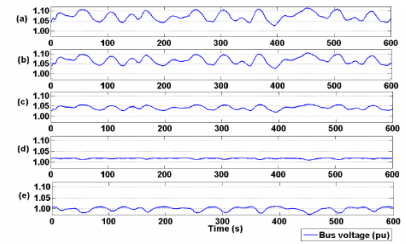


Fig 3. Bus 2 voltages for various DFIG excitations. (a) PF = 0.95 lagging, (b) PF = 0.98 lagging, (c) UPF, (d) PF = 0.98 leading, (e) PF = 0.95 leading.

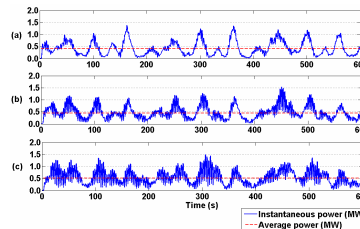


Fig 4. Instantaneous raw power for 6 WECs arranged with ' $d = (a) 0.25 \lambda_{pk}$, (b) $0.375 \lambda_{pk}$ and (c) $0.5 \lambda_{pk}$; ' $\alpha = 0^\circ$ '.

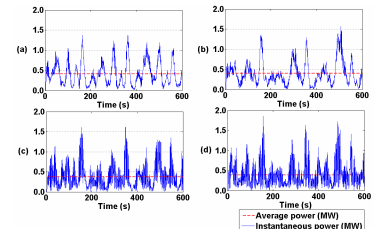


Fig 5. Instantaneous raw power for 6 WECs arranged with ' $\alpha = (a) 0, (b) 30, (c) 60, (d) 90$ degrees; ' $d = 0.25 \lambda_{pk}$ '.

Conclusions

- The optimum spacing, of odd-number multiples of one quarter of the dominant wavelength, aligned with the predominant wave direction in realistic sea conditions produces some power smoothing, which results in a smoother bus voltage.
- Short term voltage variations may be reduced by onboard energy storage or fast acting power electronic control of the power produced by the generators in the WECs.

References

1. A. E. Kiprakis, A. J. Nambiar, D. I. M. Forehand, and A. R. Wallace, "Modelling Arrays of Wave Energy Converters Connected to Weak Rural Electricity Networks," in Proc. of the 1st Int. Conf. on Sust. Pwr. Gen., China, 2009.