2021 NC Renewable Ocean Energy Symposium
May 24-25

Coastal Studies Institute
A MULTI-INSTITUTIONAL RESEARCH PARTNERSHIP

Estimation of Power Generation Profile of Offshore MHK Microgrid Cluster

Rodney Itiki, Madhav Manjrekar, Badrul Chowdhury
Department of Electrical and Computer Engineering
Energy Production & Infrastructure Center (EPIC), University of North Carolina at Charlotte, NC 28223-0001

UNC CHARLOTTE
Energy Production and Infrastructure Center

Objectives

The development of an algorithm that estimates power profiles of MHK farms, based on daily superficial water speed from NOAA HF radars, and spatial distribution of MHK turbines, and microgrid clusters is useful for the design of a MHK farm harvesting energy from the fast waters of the Gulf Stream off NC coast.

Fig.1 Offshore MHK microgrid clusters of the NC coast

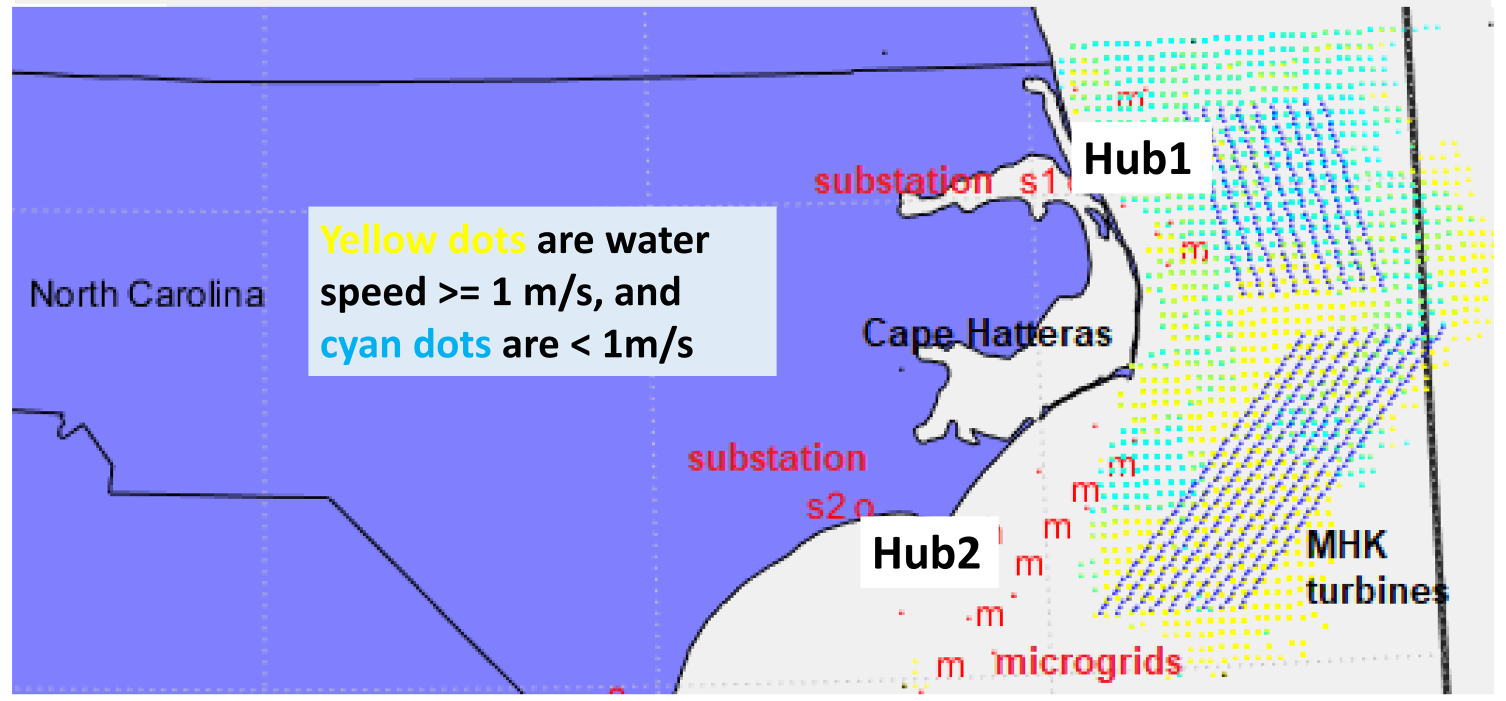
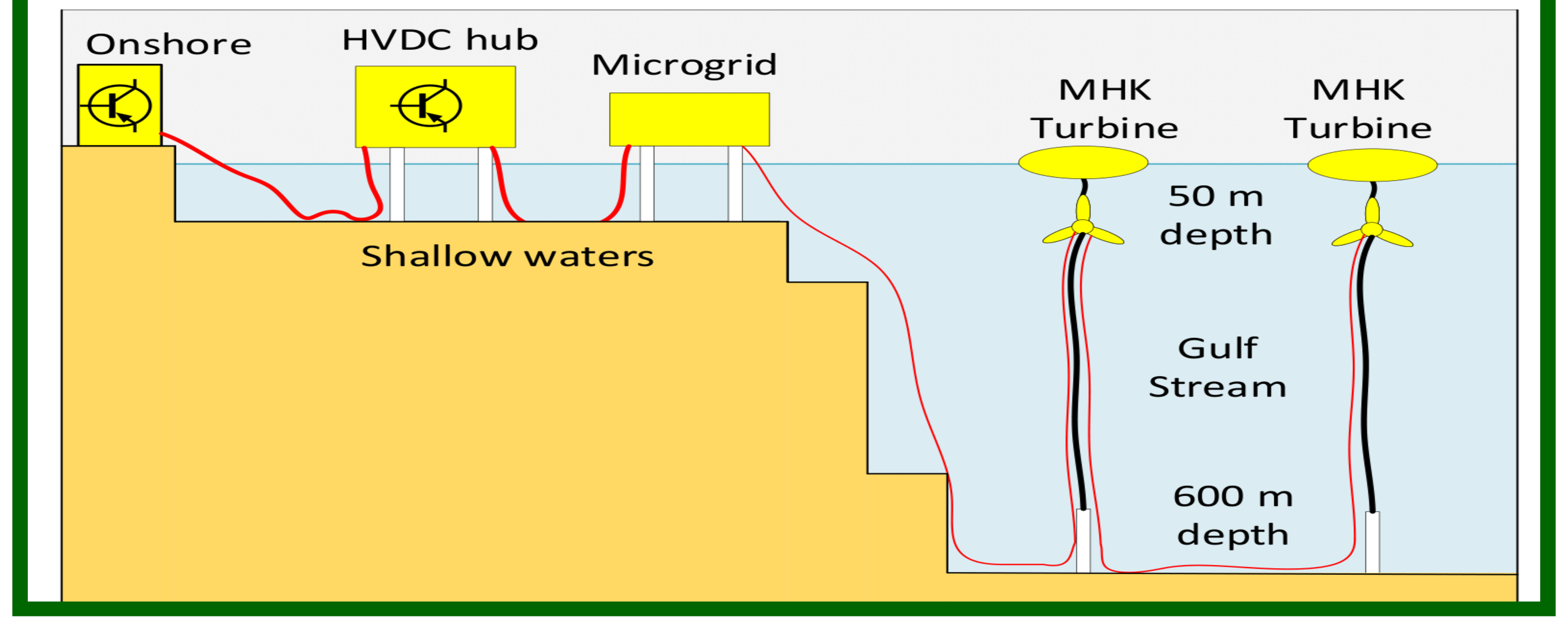


Fig. 1 shows dark blue dots, representing the proposed location of two MHK farms. The power of 270 turbines in the northern farm is collected by three microgrids and dispatched to hub 1. In the southern farm, six microgrids collect and dispatch the power of 540 turbines to hub 2. Each turbine capacity is 2 MW, totalling a capacity of 540 MW in hub1 and 1080 MW in hub 2. The yellow dots indicate high values of water speed located in the southern farm (hub 2).

Fig.2 Cross section of MHK microgrid cluster



Acknowledgements

The authors gratefully acknowledge Faria Kamal, Prithwiraj Roy Chowdhury for their comments and discussions; and the Energy Production and Infrastructure Center (EPIC) and the UNC Coastal Studies Institute for their funding support.

Fig. 3 MHK Power Profile Algorithm

1. Populate array of hubs, microgrids, and MHK turbines in the US map attributing latitude and longitude to each of them
2. Open and reframe the seawater speed data from NOAA HF radar
3. Model MHK turbine power curve (Power vs water speed)
4. Start loop calculation of hub power and water mean speed.
5. Start calculation loop of power profile for each turbine.
6. Find closest coordinates of water speed data based on the location of each turbine, and capture the seawater speed data.
7. Calculate a turbine power profile based on water speed
8. Store the power profile agregated by each MHK turbine
9. Store the profile of power and water mean speed of each hub.
10. Plot the map with location of substations, hubs, and turbines
11. Plot over the map the speed data from the HF radar
12. Plot the profile of power and water current mean speed.

Conclusions

This research developed an algorithm implemented in MATLAB for the estimation of MHK power generation profile of microgrid clusters, potentially useful for the design MHK farms off North Carolina coast. This profile is also important to utility companies to plan reinforcements of existing transmission lines to receive the new MHK generation. The average capacity factor of the southern farm fluctuates around 14% and 46%. Since the power fluctuation is significantly high, demand side management by intermittent hydrogen production and battery energy storage for peak shaving and valley filling are important topics for future research.

Fig. 4 Single line diagram

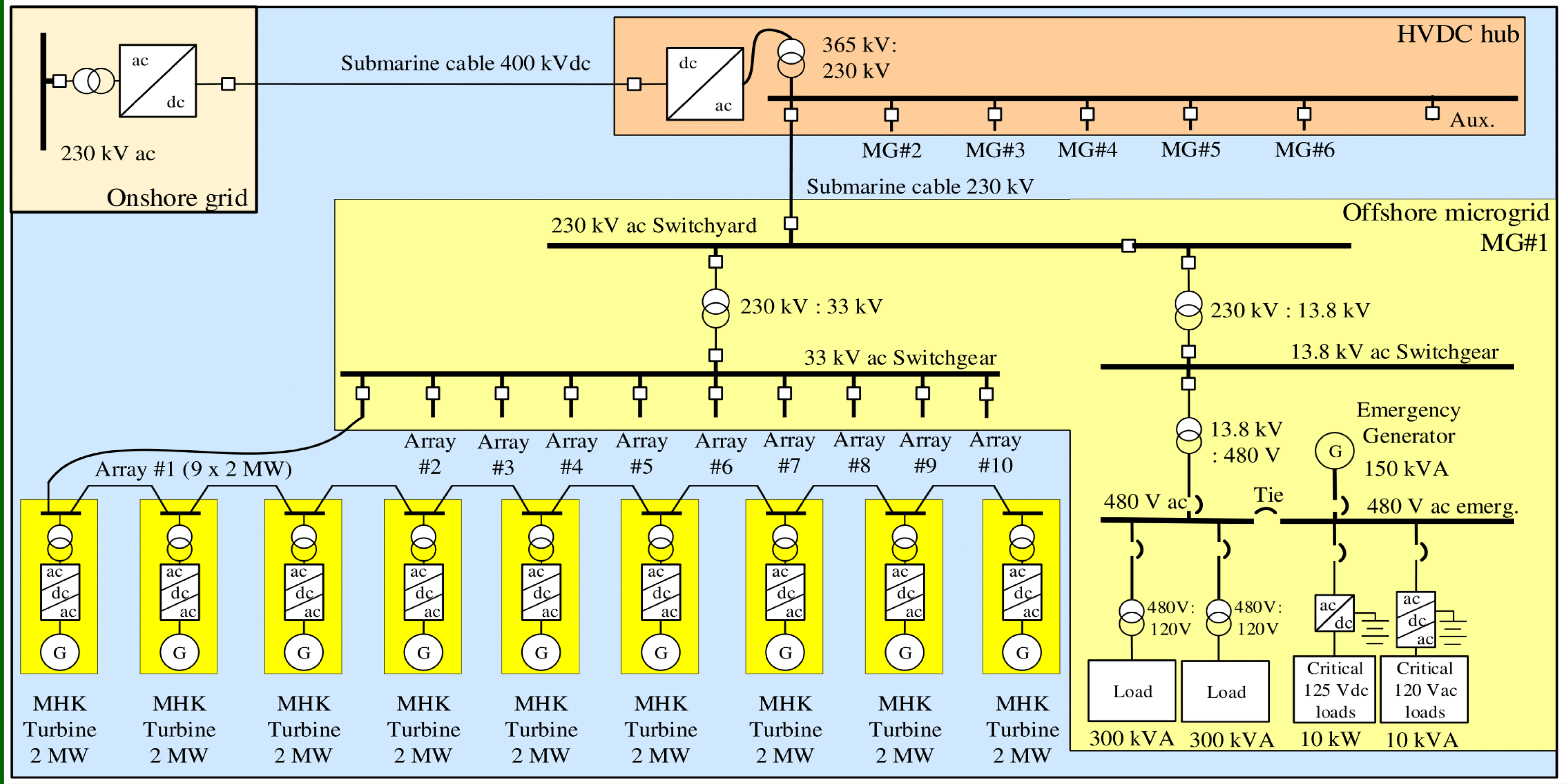


Fig. 5 MHK power and mean water speed profiles

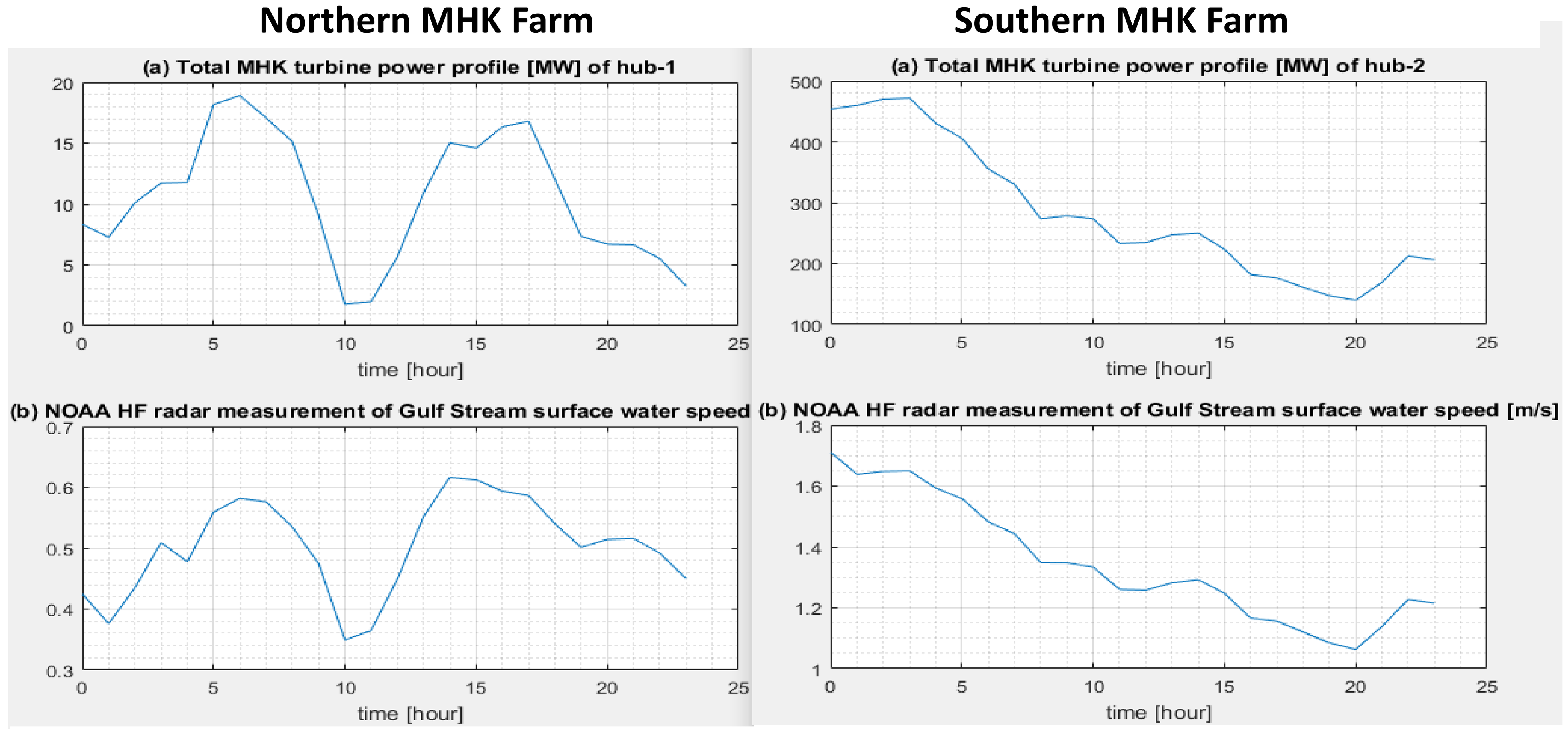


Fig.5 shows the resulting hourly profiles of power and mean water speed in hub 1 (left side curves) and hub 2 (right side curves). Hub 2 (southern MHK farm) yields 150 – 470 MW, i.e., it yields significantly more power than hub 1 (2 – 19 MW).

References

[1] **R. He et al.**, “Gulf stream marine hydrokinetic energy resource characterization off Cape Hatteras, North Carolina”, in Proc. *OCEANS 2016*, Shanghai, 2016, pp. 1-4.

[2] **R. Itiki, S. G. D. Santo, C. Itiki, M. Manjrekar, Badrul H. Chowdhury**, “A comprehensive review and proposed architecture for offshore power system”, *Int. Journal of Electrical Power & Energy Systems*, vol.111, 2019.

[3] **R. Itiki, S. G. D. Santo, E. C. M. Costa, R. M. Monaro**, ”Methodology for mapping operational zones of VSC-HVDC transmission system on offshore ports”, *Int. Journal of Electrical Power & Energy Systems*, Vol. 93, 2017.

[4] **R. Itiki, F. Kamal, K. Singh, P.R. Chowdhury, M. Manjrekar, B.H. Chowdhury**, Offshore Microgrid platform for Marine Hydrokinetic Energy and Hydrogen production in North Carolina, Poster presented at: *International Conference on Ocean Energy (ICOE)*, April 28-30, 2021, USA.