The ocean wave energy potential along US coastline is 64% of the electricity generated from all sources in the US. Over 53% of the population live within 50 miles off the coast, so ocean waves offer ready opportunity to provide electricity without long-distance electricity transmission. However, the ocean wave energy harvesting is still in its infant stage worldwide. The power takeoff (PTO), the machinery to convert the mechanical energy into electricity, is widely considered as the single most important element in wave energy technology, and underlies many of the failures to date (A. Falcao 2010). Revolutionary power takeoff beyond the direct and indirect drives is urgently needed in order to realize the vast blue energy potential from the ocean. This talk will present the design, dynamics modeling, power electronics control, lab test, wave tank test, and ocean trial of a "mechanical motion rectifier" based power takeoff, which converts the irregular oscillatory wave motion into regular unidirectional rotation of the generator. Lab tests show that up to 80% mechanical energy conversion efficiency was achieved with reduced force in the PTO motion system. The rotatory inertia and two-body system design can further increase the power output in a large frequency range. Wave tank test and ocean trail also validated the high efficiency and reliability.

Bio Sketch: Lei Zuo completed his PhD in Mechanical Engineering from MIT in 2004. After working on industry for four years, he joined in State University of New York in 2008 as an assistant professor and was promoted to associate professor in 2013. He moved to Virginia Tech in 2014 and was promoted to full professor rank in 2017. He currently serves the Director of NSF Industry-University Collaborative Research Center for Energy Harvesting Materials and Systems. Lei Zuo’s research interests include marine and hydrokinetic energy, mechatronics design, energy harvesting, vibration control, advanced manufacturing, and thermoelectricity. Since 2018 he has secured over 14 million US dollars of research funding ($11M as the PI), including ten projects from US Department of Energy, National Science Foundation, Energy Protection Agency, National Academy of Sciences, New York and Virginia States on the design, dynamics, control, and applications of ocean wave energy conversion. Lei Zuo has published 110 journal papers and over 150 conference papers, including 6 with best paper awards and 2 with best student paper awards. He graduated 10 PhD and 19 MS students and is currently advising 12 PhD and 7 MS students. The ASME recognized him as "a pioneering researcher in energy harvesting, especially at larger energy scale" with its 2015 Thar Energy Design Award. Zuo is also the sole recipient of the 2017 ASME Leonardo Da Vinci Award/Medal, for his "eminent achievement in the design or invention of a product which is universally recognized as an important advance in machine design". He won R&D Awards twice (2015 and 2011) from R&D Magazine, which recognizes the top 100 technology innovations in the word of the year. He currently serves as a technical editor for IEEE/ASME Transactions on Mechatronics and associate editor for ASME Journal of Vibration and Acoustics and IFAC journal Mechatronics.