



CCPI “Annual” Report Executive Summary—January 2010-June 2011

About CCPI

Center for Carbon-free Power (CCPI) undertakes scientific research, educates the next generation of students, actively engages industry, policy makers and the public, and facilitates the transition to power generation using carbon-free geophysical flows. These power sources include surface wind, geostrophic winds, and ocean currents. The primary areas of inquiry are offshore wind power and vehicle-to-grid/grid-integrated vehicle (V2G/GIV) technology as a means of electricity storage. The center’s focus is on electricity and transportation because these two sectors account for the largest fractions of human CO₂ production. CCPI also focuses on the co-benefits of offshore wind power, including reduction in health impacts of energy generation and the life-cycle environmental effects of energy production, economic development and job creation, price stability, and energy independence. CCPI researchers have appointments in four University of Delaware (UD) colleges—Earth, Ocean and Environment (CEOE); Engineering; Business; and Agriculture and Natural Resources—and conducts leading-edge research in renewable energy including Mechanical Engineering of wind turbines; Meteorology; Public Policy; Composites; Business, Economics and Finance; Bio-corrosion; and Geophysical and Geotechnical Aspects of Offshore Wind. CCPI is housed administratively within CEOE.

A Transitional Period

2011 was a time of transition. From its inception in the fall of 2008 Willett Kempton had served as CCPI’s Director. In 2011, Dr. Kempton transitioned into the newly-created position of Research Director, while Jeremy Firestone assumed the position of Center Director. We thank Dr. Kempton for his service as Director. An additional scientist - John Madsen – became a governing member of CCPI - bringing the total to seven. In addition, a second category of membership was created to both recognize existing, and facilitate future, scientific collaboration. The following individuals are CCPI research scientists.

Governing Scientists/Members



Jeremy Firestone, Director, and Professor, Marine Policy, School of Marine Sciences and Policy (SMSP); Willett Kempton, Research Director, and Professor, Marine Policy & Electrical & Computer Engineering; Suresh Advani, Professor, Mechanical Engineering & Associate Director, Center for Composite Materials; Meryl Gardner, Associate Professor of Marketing, Lerner College of Business and Economics; John A. Madsen, Associate

Professor, Department of Geological Sciences; Ajay Prasad, Professor of Mechanical Engineering and Director, Center for Fuel Cell Research; Dana Veron, Associate Professor, Physical Ocean Science and Engineering (POSE), SMSP

Affiliated Scientists/Members

Christina Archer, Associate Professor, POSE & Geography
Jeffrey Buler, Research Assistant Professor, Entomology and Wildlife Ecology
James J. Corbett, Professor, Marine Policy and Civil and Environmental Engineering
Stephen Dexter, Professor of Applied Science and Marine Biology, SMSP
Fouad Kiamilev, Professor, Electrical and Computer Engineering
George Parsons, Professor, Marine Policy and Economics
Bonnie Ram, Research Scientist, CCPI and Independent Consultant, Ram Power, LLC
Greg Shriver, Assistant Professor, Entomology and Wildlife Ecology
Fabrice Veron, Associate Professor, Physical Ocean Science and Engineering

Major Developments/Partnerships in 2010-2011

CCPI had a productive eighteen months. Its major substantive accomplishments include:

- **University of Delaware and Gamesa Technology Corporation commission a 2MW G90 coastal wind turbine adjacent to UD's campus in Lewes, Delaware.** The turbine, which was commissioned on June 11, 2010, produced 5.1 million kilowatt hours (kwh) of electricity during its first year of operation. That was more than sufficient to power UD's Lewes campus, with surplus electricity being sold to the Lewes Board of Public Works.
- **Five year research partnership with Gamesa.** Under the research agreement, the lion-share of the revenues arising from the generation and sale of electricity from the wind turbine is dedicated to wind energy research. CCPI has three members who serve on the five-member UD-Gamesa Research Committee that evaluates proposals. A 2-year avian and bat surveillance and assessment study at the wind turbine is among the funded projects.



- **Graduate research assistants/students climbed the turbine.** Two students completed safety and technical training, earned certification to climb UD's 2-megawatt wind turbine, and completed their first climb to the nacelle. They took measurements for steel samples to be mounted on top of the nacelle for corrosion research and diagnosed a malfunction with a microphone on the meteorological support at the top, used in a bird and bat study.



- The US Department of Energy (DOE) designates UD to lead a University-Industry Consortium on Offshore Wind.** The Consortium covers several research areas, including turbine corrosion in a coastal environment, wear reduction and modeling of rotating parts, tower response to wind forces, and characterization of extreme wind events. In addition, UD Professors are developing a graduate training program, with first courses to be taught during Fall 2011, one on geologic and geotechnical aspects of offshore wind, and the other on electrical engineering aspects of wind power. These courses are in addition to existing courses, such as the interdisciplinary course on offshore wind power. The Consortium includes representatives from companies whose business is in wind turbines, wind transmission, wind testing and certification services, lubricants, meteorology, sensors, and others. The University of Maryland and Old Dominion University are also partners.
- UD-NREL 2010-2015 Cooperative Research and Development Agreement (CRADA).** UD and NREL agreed to undertake joint research projects, engage in personnel exchanges, and cooperate on an offshore wind turbine testing and certification site that UD is developing. The CRADA has resulted in a joint research paper that models the levelized cost of offshore wind energy, which will be published in *Energy Policy*, and three UD graduate student internships at NREL's National Wind Technology Center (NWTC) in Boulder. UD is taking the lead on development of the test site and finding other partners, while NREL, building on its experience in land-based turbine testing, will provide personnel to test the offshore wind turbines at the test site for certification by international certification entities.
- Vehicle to Grid Power and the Grid Integrated Vehicle.** A multi-year project funded by the US Department of Energy's "Smart Grid" program was completed this year. Four electric vehicles (EVs) with V2G capability were built for the Delaware State fleet, and two additional ones were built for the UD fleet (making 3 currently at UD and a total of 7 in the state). These vehicles were dispatched as power resources to PJM Interconnection; this type of service has previously been provided only by power plants, not a fleet of electric cars.



Student Education and Research

CCPI has a growing number of undergraduate and graduate students who serve as Center research assistants while pursuing degrees. Six graduate students matriculated in the fall 2010 and two additional graduate students will be matriculating in fall 2011. In addition, three undergraduate students conduct research with the Center. Three PhD students and two master's students graduated during the past year and a half. They have gone on to positions at the US Department of the Interior, University of Hawaii, and PJM Interconnection or are working as independent consultants.

Wind/V2G Publications

During the last year and a half, CCPI researchers published ten papers related to offshore wind or V2G. Six papers were published in peer review journals—*Land Economics*, *Proceedings of the National Academy of Sciences*, *Energies*, *Energy for Sustainable Development*, *Transportation Research Part C*, *Journal of Resource, Energy and Environmental Economics*—two are published as book chapters, and two were published in peer-reviewed conference proceedings. Many of these publications can be found at <http://www.ceoe.udel.edu/windpower/articles.html> or <http://www.udel.edu/V2G/ArticlesandPapers.html>.

Engagement

CCPI researchers provide policy advice to federal and state policymakers and regulators, and are active participants at national and international workshops, presenters at conferences, and visiting lecturers at universities. Activities included commenting on DOE's RFI regarding Offshore Wind Demonstration Projects, the IPCC's Special Report on Renewable Energy (SRREN), NREL's 2010 report on Offshore Wind Energy, NOAA's review of Delaware's Interstate Consistency program as it relates to offshore wind, proposed US Army Corps of Engineers rules, and a Senate Whitepaper on Clean Energy Standards. A few other recent highlights follow.

- A V2G talk at the 2010 AAAS Annual Meeting in San Diego
- Briefing for a panel convened by the Environmental and Energy Study Institute at the Rayburn House Office Building on the role of electricity as a transportation fuel
- Organization of and moderating offshore energy panels, 2010 Global Oceans Conference, Paris
- Presentation on the benefits of offshore transmission to level offshore wind at the American Wind Energy Association's (AWEA) 2010 Offshore Wind Conference & Exhibition, Atlantic City, NJ
- Invited panelist on social acceptance of wind energy, AWEA WINDPOWER 2011, Anaheim, CA
- Workshop Planning Committee Member and Breakout Session Leader, Transportation Research Board of the National Academy of Sciences' (NAS) Offshore Wind Energy Workshop, Washington, DC
- On behalf of the NAS, presentation of findings to a 2010 DOI-DOE workshop, Atlantic City, NJ
- Invited testimony, on OCS Energy to the National Academies Committee on Earth Resources
- Invited Testimony before Maryland Senate Finance Committee
- Participation on University Collaboration on Wind Energy White Paper sponsored by Cornell
- Contribution to a US Country Report that was prepared for the International Energy Agency

