# Energy Storage by Supercapacitors Based on Carbon Nano-Onions

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http://engineering.unl.edu/academicunits/electricalengineering/faculty-staff/lu.shtml

Abstract

With the explosive development of solar and wind energies, energy storage becomes critical due to the fact that energy generation and consumption do not necessarily have the same cycles. As a result, it is imperative that energy storage and harvesting technologies should be developed and integrated as a total energy solution. Among energy storage devices, supercapacitors exhibit distinct advantages, such as fast charge/discharge time, long cycle life, little heat loss, and predictable declination. In a supercapacitor, the capacitance is proportional to the electrode surface area. Therefore, the key element to achieve a high storage density is to use highly conductive electrodes with high specific surface area (SSA). Carbon in various forms has been extensively used as the electrode material in supercapacitors due to its low cost, high SSA, chemical stability and easy availability. In this proposed research, we will develop high-density supercapacitors using carbon nano-onions (CNOs) as the electrode material and integrate the supercapacitors with wind turbine generators. CNOs are nanometric concentrically layered spherical carbon clusters, which show enormously large SSA and excellent electrical conductivity. The PI's group has developed an efficient process to produce CNOs in large quantity under mild conditions in open air. The CNOs have average diameters ranged from several nanometers to tens of nanometers, which promise a high SSA for large storage density. Compared with other carbon electrodes, CNOs are much cost effective and possess much larger SSA. Successful completion of this project will provide a technically and economically viable solution for energy storage in wind and solar energy generation using high-energy-density supercapacitors.

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Deteriorating global warming and depleting fossil fuel reserve put forward the requirements for sustainable, renewable, and green energy resources [1]. As a result, explosive development on solar and wind energy has been witnessed in recent years [1-5]. In order to meet the requirements of frequency and active power regulation, energy buffer and storage devices are required to dynamically match the intermittency of wind energy [6]. Supercapacitors show prominent advantages in immediate charging and high energy uptake. It has been shown that energy storage efficiency could be significantly improved by using supercapacitors to buffer the wind turbine. Therefore, supercapacitors of high energy density and low cost are urgently required.

In this project, the PIs will develop high-density supercapacitors using carbon nano-onions (CNOs) as the electrode material with high efficiency and low cost. The capacitance is proportional to the electrode surface area [7]. Therefore, the key element to achieve a high energy storage density is to use highly conductive electrodes with large specific surface areas (SSA) [7]. CNOs are nanometric concentrically layered spherical carbon clusters, which show enormously large SSA, excellent electrical conductivity, and remarkable chemical stability [8-10]. The PI's group has developed an efficient process to produce large quantity of CNOs at a low cost in open air. Average diameters of CNOs are ranged from several nanometers to tens of nanometers, which promise a higher SSA for large capacitance. Compared with other carbon electrodes, CNOs will provide a cost-effective solution with competitive performance. Successful completion of this project will provide a technically and economically viable solution for energy storage using supercapacitors of high-energy density. Techniques developed from this project will be integrated into the DOE supported national renewable energy program in Nebraska for developing wind energy.

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