Electrical Energy Storage and its Importance to Sustainable Renewable Energy

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The projected doubling of world energy consumption within the next 50 years, coupled with the growing demand for low- or even zero-emission sources of energy, has brought increasing awareness of the need for efficient, clean, and renewable energy sources. Energy based on electricity that can be generated from renewable sources, such as solar or wind, offers enormous potential for meeting future energy demands. However, the use of electricity generated from these intermittent, renewable sources requires efficient electrical energy storage which is one of the major limiting factors for wide-spread adoption of renewable energy. Energy storage represents perhaps the “ultimate” solution to the problem of intermittent generation from renewable sources. Energy storage increases the usefulness of renewable sources in two ways. First it absorbs excess PV or Wind and allows the renewable energy to be used when it is not produced- in the evening, on cloudy days, calm days with no wind, etc. Just as important, but perhaps less obvious, is the increased flexibility in utility system operation allowed by large-scale energy storage deployment. A traditional electricity system dependent on base-load plants will have limited headroom for PV, Wind, and other intermittent generators, and allow the renewable energy generated from PV or Wind to be used only in the variable part of the daily load curve. The combination of the renewable energy generated from PV or Wind and storage could effectively replace base-load generation, and thus increase the penetration of variable source generation in the system.

In addition, greatly improved EES systems are needed to progress from today’s hybrid electric vehicles to plug-in hybrids or all-electric vehicles. The performance of current small-scale electrical energy storage technologies (batteries and capacitors) falls well short of requirements for using electrical energy efficiently in transportation. For example, electrical energy storage devices with substantially higher specific energy and power densities and faster recharge times are needed if all-electric/plug-in hybrid vehicles are to be deployed broadly as replacements for gasoline-powered vehicles. Improvements in EES reliability and safety are also needed to prevent premature, and sometimes catastrophic, device failure. In this talk the importance and potential role of energy storage for wide-spread adoption of renewable energy will be discussed. Leading-edge developments in electrical energy storage and the advantages and disadvantages of the nanoscale in materials design for these storage devices will also be discussed in detail.