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Water-Energy Systems: Distributed Coupled Cyber-Physical Networks

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More than 200 billion gallons of water are used daily in the US for production of energy. In turn, more than 12% of national energy consumption is required to deliver and treat water supplies. Trends indicate the world is moving towards more water-intensive energy (e.g., biofuels, carbon capture) and more energy-intensive water (e.g., desalination, long-haul transfer). These intertwined water and energy needs—the Water-Energy Nexus—pose significant economic, political, and environmental challenges.

Our thesis is that there is a need to develop an integrated engineering systems approach to the management of water and energy networks, focusing on their critical infrastructural interdependencies and considering engineering, scientific, policy, economic, environmental and societal facets. Rigorously addressing system-level challenges will require fundamental advances in how we understand and manage distributed coupled cyber-physical networks involving multiple spatial and temporal scales. Water-energy systems can be considered to have five-layers, with inputs and outputs for each layer: material, water, energy, information, and capital. Five criteria will be used to analyze and assess such systems: Sustainability (material layer), Efficiency and Recycling (energy and water layers), Security (information layer), Affordability (capital layer), and Resiliency (coupling across all 5 layers and including climate and other environmental factors). Information (cyber) technology will be a key enabler for this new class of systems, boosting improvements in all five of these criteria and complementing technological advances in individual strata.