



A System of Systems (SoS) Approach to Sustainable Energy Planning

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The general policy of mandating fossil fuel replacement with "green" energies may not be as effective and environmental-friendly as perceived, due to the secondary impacts of renewable energies on different natural resources. An integrated systems analysis framework is essential to developing sustainable energy supply systems with minimal unintended impacts on valuable natural resources such as water, climate, and ecosystem. This presentation discusses how a system of systems (SoS) framework can be developed to quantitatively evaluate the desirability of different energy supply alternatives with respect to different sustainability criteria under uncertainty. Relative Aggregate Footprint (RAF) scores of a range of renewable and nonrenewable energy alternatives are determined using their performance values under four sustainability criteria, namely carbon footprint, water footprint, land footprint, and cost of energy production. Our results suggest that despite their lower emissions, some renewable energy sources are less promising than non-renewable energy sources from a SoS perspective that considers the trade-offs between carbon footprint of energies and their effects on water, ecosystem, and economic resources. A new framework based on the Modern Portfolio Theory (MPT) is also proposed for analyzing the overall sustainability of different energy mixes for different risk of return levels with respect to the trade-offs involved. It is discussed how the proposed finance-based sustainability evaluation method can help policy makers maximize the energy portfolio's expected sustainability for a given amount of portfolio risk, or equivalently minimize risk for a given level of expected sustainability level, by revising the energy mix.