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Title: Multi-Stakeholder Design of Sustainable Complex Energy-Water Systems Using Real-Time Feedback

Abstract: Designing complex interdependent systems, such as meeting energy and water demand while minimizing cost and environment impact, requires determining the relationship between design choices and design objectives, then balancing the objectives of heterogeneous stakeholders. When the relationship between design and objectives is not transparent due to problem complexity, decision-makers may settle on sub-optimal solutions due to bounded rationality. This work proposes a new technique for complex system design called Concurrent Assessment and Design of Systems (CADS) that provides stakeholders feedback on the relationship between individual and group design decisions and objectives. We tested the approach using a mixed within- and between-subject experiment to design a wastewater management system for shale gas exploration, finding that compared to individual designs and informal group collaborations, real-time performance feedback in addition to informal collaboration improved group decision-making and yielded design solutions closer to the Pareto frontier. This result updated previous research on the effects of collaboration and feedback, and found that unlike prior studies, feedback was the necessary component for improving team performance, while collaboration by itself was insufficient. The results highlight opportunities to incorporate real-time feedback into decision-making around complex systems and policy analysis, such as utility planning exercise and water management strategies.