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Given the investigated researches, several considerable gaps are detected as follows so that addressing them is crucial and inevitable for facilitating the modernization process of future MCENs.

The future MCENs with 100% RESs require different flexibility improvement technologies to alleviate the negative effects of stochastic fluctuations of RESs on continuous energy serving. Although employing energy-sharing technologies as one of the effective ways of flexibility enhancement is essential for ensuring a secure energy supply, the capable technology and an appropriate energy market structure are not offered in recent works for MCMGs to enable them for multi-energy trading aiming to gain different valuable achievements and facilitate the modernization process of MCENs.

The new hybrid DRCC and SP method is proposed to simultaneously benefit the advantages of both the DRCC and SP approaches for suitably modeling the stochastic behaviors of various uncertain parameters with diverse variation patterns aiming to elicit more realistic results. This innovative uncertainty quantification method increases the ability of the system in the realistic modeling of uncertainties to provide a robust framework for MCMGs to have purposeful energy interactions against the unfavorable variations of RESs.

The holistic techno-environmental-economic model is offered for the coordinated operation of the EPS, NGG, and DHN to realistically model their interactions by using the complete and exact network modeling for them. The proposed model covers the interconnected structure of the EPS, NGG, and DHN with five energy carriers including hydrogen, natural gas, heating and cooling, and electrical energy that allows MCMGs to benefit from multi-energy interoperability for simultaneously reaching technical, environmental, and economic goals.

The integrated demand-side multi-energy management schemes (IDSMEM) are developed considering the curtailable and shiftable attributes of elastic demands to increase the system"s flexibility in managing and serving unbroken energy. The proposed IDSMEM enables end-users to participate in multi-energy management programs to not only assist in establishing energy balance but also use this opportunity to increase their economic benefits.

Schematic of the proposed hybrid structure for MCMGs. This structure creates a revolution in energy grids by sustainably integrating several dependent energy networks with multifarious energy carriers. It supports the modernization of future energy grids by enabling the structure to 100% generate clean energy that is realized by developing a novel transactive energy architecture. It also presents the state-of-the-art way of multi-energy

interactions that models energy dependences among various energy grids.

Schematic of the intended test system. The proposed system is the integrated structure of EPS, NGG, and DHN that offers a systematic area of model for facilitating multi-energy interactions in the local area of Chicago.

Optimal scheduling of the hydrogen systems. It is a clear view of how energy conversion technology can enhance the capability of operational models in making future energy grids more flexible and sustainable.