Abstract:
Extreme weather is becoming a critical threat to electrical grids. In particular, the destructive potential of hurricanes was highlighted in 2017 when the U.S. struggled to handle the aftermath of Hurricanes Harvey, Irma, and Maria. On the other hand, the rapid modernization of the power grid into a ‘smart grid’ -- which incorporates distributed energy resources (DERs) in the form of portable microgrids, localized renewable energy, storage devices, and electric vehicles -- provides government agencies and utilities increased flexibility in handling grid damage. To address the potential of smart grid technologies and DERs to increase grid resilience, I devise a two-stage stochastic mixed-integer linear program (SMIP2) that determines optimal pre-storm resource allocations to minimize storm-induced losses. The framework accounts for uncertainties in the locations and severity of network damage, as a function of the storm’s evolving surface wind field. Furthermore, the framework includes models of multi-period repair scheduling and multi-master operation of resulting islanded microgrids. Regarding the distribution over network damage, I demonstrate that inclusion of hurricane track forecast uncertainty using Forecasts of Hurricanes using Large-Ensemble outputs (FHLO) increases the expected damage, and that the damage ‘critical zone’ is well-defined under restrictive assumptions. Regarding the solution approach for solving SMIP2, we devise an approach based on L-shaped Benders Decomposition (LBD), derive tighter Benders cuts that ensure faster LBD convergence, and demonstrate that LBD significantly reduces computation time with minimal loss in optimality. These contributions illustrate the utility of proactive strategies, stochastic modeling of damages, and network-based approaches in ensuring resilient and sustainable operation of electrical grids during extreme weather events.

Bio:
Derek Chang recently finished his 5th year as a Ph.D. student in the Resilient Infrastructure Networks Lab (RESIL), led by Professor Saurabh Amin. He is working towards a joint PhD degree between CEE and the Center for Computational Science and Engineering (CCSE). Derek’s research focuses on resource allocation and response strategies for network resilience to extreme weather. Before beginning his Ph.D., he obtained a B.S. in CEE and M.S. in Atmospheric Science, both at MIT. Derek is a recipient of the National Science Foundation Graduate Research Fellowship and the MIT Martin Sustainability Fellowship. In 2019, he interned as a Data Scientist at Spacemaker AI.