Dr. Amin's R&D Team – Foci and Results:
Cyber-Physical Secure, Resilient, Sustainable and Smarter Critical Infrastructures

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Summary: Our goal is to better understand, model, and manage the true dynamics of complex interdependent critical infrastructure systems, including energy, communications, finance, transportation networks, in order to enable stronger, smarter, more resilient, more secure and sustainable local/national/global infrastructures.

We develop and apply analytical and multi-domain modeling, simulation and testing methodologies to assess the effects of smart grid technologies on distribution system operations and performance, including microgrids applicable to DoD bases. Our results integrate aspects of cyber-physical security, dynamic price and demand response, mix and placement of storage devices, integration of wind, solar and intermittent distributed energy resources, combined with sensing, communications, and dynamic optimization and reconfiguration. Applying this comprehensive systems approach, performance results for several distribution system test cases have been performed.

Projects and results for potential technology transfer:

1) **Distribution Systems:** Self-organizing microgrids with integration and optimization of storage devices and PHEVs with the electric power grid. Assessments performed on several IEEE test cases as well as on the UM-Morris Campus, combined with practical costs, risk and reliability analyses.

2) **End-to-End Power Generation, Transmission and Distribution Systems Overlaid with Communication Networks and Markets:** a) Fast power grid simulation and risk assessment (12-15 fold speedup in dynamic risk assessment), and b) Distributed state estimation and implementation of smart software agents as distributed computer.

3) **Cyber-physical Security:** The objective of this cluster of projects is to model, design and develop reconfigurable and distributed smart energy systems supported by secure sensing/wireless communication network overlay and fault-resilient real-time controls. Projects include: a) Security of cyber-physical infrastructure, development of resilient real-time system for a secure and reconfigurable end-to-end power system; and b) Security analyses of autonomous Microgrids: Analysis, Modeling, and Simulation of Failure Scenarios, and Development of Attack-Resistant Architectures.

4) **Smart Grid Assessments for communities, UM-Morris, and UMore Park**: Due to its size, complexity, and cost, the transformation of the existing electrical grid to a smart self-healing system will need to occur in several stages over time with equipment being gradually replaced as it reaches the end of its operating life. Focusing on smart grids for communities and at a college campus level, university microgrid projects offer very practical environments for testing Smart Grid systems. We employ a holistic systems approach for all of our work on this project. It engages faculty, postdocs, researchers, undergraduates, consumers from across the local community, as well as utilities from the wider Smart Grid coalition in Minnesota to build consensus on issues such as microgrid configuration, cost-effectiveness, and security.