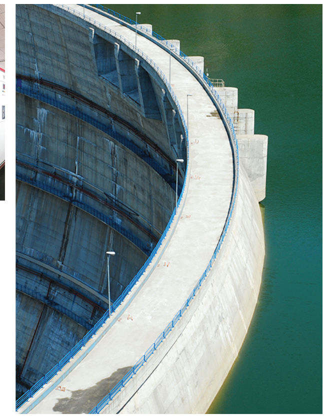
Energy

Electrical & Computer Engineering









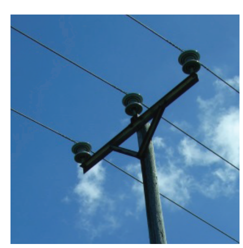
The functioning of today's society heavily depends on electric energy. Without electricity we would not have lighting, refrigeration, air conditioning, computers, elevators, ATM machines, gas pumps – most essential elements of our daily lives would stop working. Blackouts, such as in 2003, affect the lives of millions of people and result in billions of dollars in economic losses.

Overall, the electric energy consumption in the U.S. amounts to roughly 4 Trillion kWh per year, of which about 67% is produced from fossil fuel sources (coal and gas), 19% from nuclear power, 6.5% from hydro power, 5.5% from other renewables (wind and solar), and the remaining amounts from miscellaneous sources and imports. The ambition to render this system sustainable has turned energy into one of the hottest research areas in electrical engineering. While the most promising resources to provide clean electric energy are wind and solar power, these resources are inherently variable and intermittent.

To ensure a balance between energy generation and consumption, alternative sources (adjustable demand, storage, and generators) have been utilized. However, some alternative sources are not reliable due to their outputs being hard to predict, leading to increased uncertainties. Moreover, it is not just a question of matching supply and demand but also ensuring secure transmission from generation to consumption.

The transition from large power plants to smaller ones, in addition to the distributed nature of these resources, leads to new and more variable power flow patterns. It is critical to transform the rigid legacy grid into an agile system capable of providing capacity where needed. This "smart grid" could lead us to clean electric energy and secure, reliable operation of the power system. The term "smart grid" merely entails increased use of information, communication, and sensing technology to collect high-resolution data to enable intelligent decision-making.

However, there are questions that still need to be addressed; how will data be translated into useful information? What information needs to be exchanged among entities? How can this be done in a secure way?


Electrical & Computer ENGINEERING

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ECE expertise

Research in energy systems requires expertise in many areas beyond electric power systems, including; software engineering, information and communication technology, control theory, cyber security and automation technology. With strengths in all of these fields, ECE is well positioned to make innovative contributions in the energy area.

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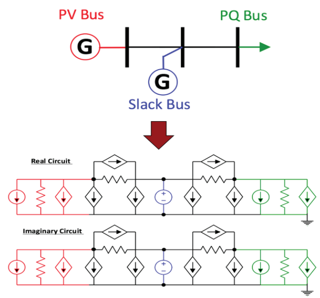
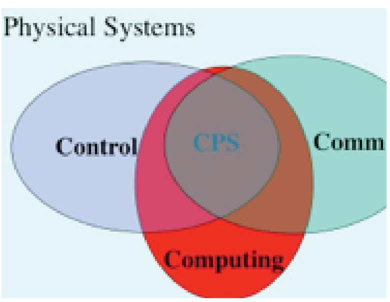
SUGAR: Simulation of Unified Grid and Renewables



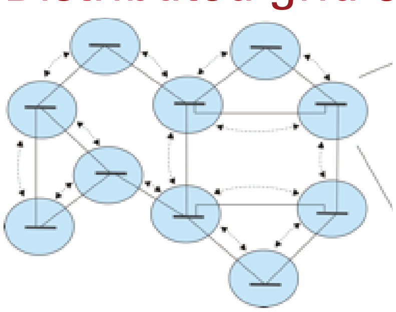
The monitoring and reliability of the electric power grid requires analysis capabilities beyond the existing software tools that are used to simulate power flow. Traditional power flow simulation software tools lack the robustness and scalability that is needed to emulate a complete modern grid, and are based on models that are becoming obsolete for emerging technologies such as renewables and power electronic based devices. Researchers in ECE have developed a new approach based on an equivalent circuit representation that is analogous to that used for design of electronic circuits. Their tool SUGAR, provides unprecedented capabilities for modeling, analysis and optimization of electric power grids of continent scale.
Contact: Larry Pileggi

Cyber-physical systems and cybersecurity



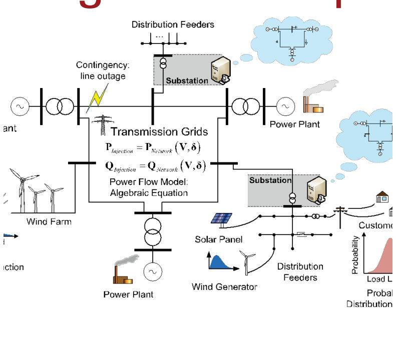
Cyber-physical systems (CPS), characterized by tight interactions between communications, computation and control, require the development of models and algorithms at the intersection of these three domains to guarantee safe and secure operation of such systems, a prototypical example of which are modern energy systems. As more sensing and communication are added to the energy system, it may become more vulnerable to faults and malicious attacks on both the information and the physical parts. Hence, it is crucial to ensure that such interruptions can be detected and counteractions taken to guarantee the security of the system.
Contact: Soummya Kar

Distributed grid optimization



The trend in the electric grid is to move towards distributed resources, grid controllers and adjustable demand. Distributed approaches are necessary to handle the thousands of these controllable elements. The design of the distributed control structure and choice of the right level of distribution is very important. Researchers in ECE have developed a range of methods that allow for a fully distributed operation of the grid as well as determining the optimal partition of the grid for such distributed approaches. The same approaches can be used to tackle large-scale optimization problems that result from incorporating uncertainty into the problem formulation such as in stochastic or predictive optimization.
Contact: Soummya Kar

Large-scale deployment of computing



With the advent of ubiquitous and cheap computing, information technology can help provide stability and prevent blackouts, and, in normal conditions, ensure optimized operation. Researchers combine their experience in performance engineering and high-performance computing to provide situational awareness throughout the grid. For example, by deploying sub-$1,000 computing resources at every substation, every substation can have an independent simulation-based global view of the system. Based on this view and enabled by performance engineering methods, substations can make intelligent decisions and estimate the impact on the overall system.
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