

Distributed System Architectures for Energy Cyber-Physical Systems

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The Edison/Westinghouse architecture for the energy grid is highly centralized. Distributed energy CPS architectures pose many challenges. We nonetheless believe that the energy grid will inevitably move toward a more distributed, decentralized architecture due to a combination of technical and regulatory forces. The energy grid is moving toward increased use of smaller generators owned by a variety of persons and organizations. Consumers are also encouraged to make more efficient use of energy. Given these forces at work, we need to understand the challenges of distributed energy system architectures and to leverage their advantages.

Design verification is a key challenge for any distributed system; this is particularly true for a real-time control system. We can leverage results in distributed system design, such as model checking, as a foundation for the design of correct, reliable algorithms.

Security, reliability, and privacy are also key concerns. Distributed systems have some advantages in this regard: design diversity protects against certain types of attacks; nodes in the distributed system may monitor each other.

Resource allocation will require efficient distributed algorithms. Privacy is a key concern so that users do not need to expose their underlying activities when making energy transactions.

The distributed systems architecture must be carefully designed to enable all these higher level functions. This new architecture must be designed to last for a century; it must provide key basic functions while allowing for design and implementation upgrades. It must also allow for the use of the Internet for at least some control and resource allocation functions, introducing new challenges for the design of real-time control as well as security.