



Pacific Northwest
NATIONAL LABORATORY

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Control of Complex Systems Initiative

NIAC DAY@PNNL

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▶ **From Big Data to Big Control**

Develop mathematical foundations, computational tools and methods of control for emerging energy systems at ultra-large scales in terms of endpoints, sensor data volumes, and system complexity

▶ **Control architecture**

Design a framework that provides rigorous approach to coordination, joint optimization, and distributed multi-objective control of energy and other large-scale systems

▶ **Advance Department of Energy mission**

Establish advanced control programs at a national scale that can lead to large-scale deployment of more integrated, affordable, safe, secure, robust, flexible and scalable energy systems

- ▶ Although several approaches for large-scale control have been proposed, none of these are truly *scalable*. A research bottleneck is to find algorithms that are feasible when the number of controlled units tends towards millions or billions.
- ▶ Existing large-scale control solutions are impractical in the sense that to deploy them would essentially require an overnight re-engineering of the infrastructure in case. A significant research challenge is therefore to design *deployable* control architectures and algorithms that can be implemented in a seamless fashion.
- ▶ Most of our infrastructures are characterized by significant *heterogeneity*. Existing control algorithms are based on simplifying assumptions that might not be satisfied in practice. Thus, there is a need for a theory for control of large-scale heterogeneous systems.
- ▶ In order to give proof-of-concept for the proposed solutions, it is required to demonstrate them in *testbeds*. Constructing testbeds for systems with millions/billions of units is highly non-trivial.

Additional Expertise Needs

- ▶ CCSI will need access to vast amounts of *computational power* in order to simulate systems with up to millions of controlled units.
- ▶ As the testbeds will comprise not only massive numbers of simulated units but also a number of actual hardware units, the overall simulation has to satisfy *real-time constraints*, in order for the control loops to perform.
- ▶ It is intended to facilitate *federation* of the testbed to be constructed with other testbeds, which also poses constraints on the computational platform.