Energy System Co-Design with Multiple-Objectives and Power Electronics @ PNNL

Pacific Northwest National Laboratory's E-COMP initiative, short for Energy System Co-Design with Multiple Objectives and Power Electronics, aims to create scientific and technological solutions to inform design and optimal operation of a highly integrated and diverse system.

WHY E-COMP?

Our energy system is changing as more renewable generation such as wind and solar power are added to the system, in addition to accelerated deployment of responsive loads, electric vehicles, energy storage, and direct current (DC) transmission. As a result, a high percentage of electricity that is generated, transmitted, or consumed will pass through power electronics, which creates challenges for operating a reliable, resilient power system.

The E-COMP Initiative will develop distinct, enduring, and multi-disciplinary technical capabilities that enable the optimized design and operation of energy systems with high levels of power electronics (PEL)-driven devices. To achieve this, the E-COMP Initiative will develop new modeling and simulation capabilities for characterizing interacting PEL-based systems in ways suitable to inform design and operation. Additionally, multi-objective and multi-time scale optimization algorithms will be created for determining the most cost-effective infrastructure investments and operating policies for these systems.

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PNNL-SA-180924

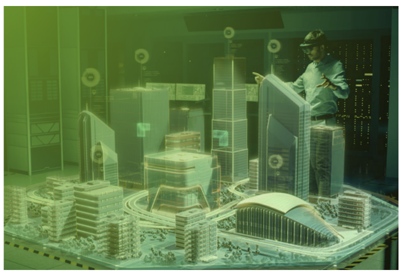
FOUR RESEARCH FOCUS AREAS

Theory and Modeling

Develop new theory and models for power and energy systems containing large numbers of PEL-driven systems. Component models parametrized for co-design will be developed along with characterizations of PEL controller interaction phenomena at different time scales, covering various problems such as local oscillations, inter-area oscillations, and weak grid-induced controller interactions.

Multi-Scale, Multi-Objective Co-Design

Apply the concept of co-design to solve the design and operation optimization problem for PEL-dominated complex energy systems. Computational optimization algorithms and software tools that enable optimal trade-offs among multiple objectives while accounting for the multi-time scale dynamics introduced by the PELs will be developed to generate investment and operational decisions.



Multi-Entity Simulation

Integrate the co-design capability and new PEL models into a broader energy system simulation platform, that will enable insight into both the impact of locally optimized entities when deployed at scale and how the evolution of the energy system should inform investment and operational decision-making at the broad system level.

Use Case Selection and Verification and Validation

Identify real-world use-cases, and extend the science of verification and validation to the complex multi-scale, multi-objective problems considered within E-COMP. This thrust will ensure that E-COMP simulation and optimization tools are verified and validated relative to real-world uses and applications.

PIONEERING THE CO-DESIGN OF FURTURE ENERGY SYTEMS

PNNL will develop some distinct, enduring, and multi-disciplinary technical capabilities:

- Characterization and modeling of energy systems with high level of PEL-driven systems to enable an understanding of stability boundaries and impact on operation and control design issues.
- Co-optimization of infrastructure investment (e.g., system selection, sizing) and operational control decisions to meet multiple objectives and constraints across multiple time scales.
- Multi-entity simulation platform for understanding the impact of distributed optimization on the broader system and to enable value modeling, energy policy evaluation, and techno-economic approaches for future energy system operation.
- A library of use cases organized around a common energy system reference model.
- Methodologies for validation based on careful design of experiment procedures that minimize experimental cost via use of empirical data, physical systems, out-of-sample model-based tests.

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https://www.pnnl.gov/projects/e-comp

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