

GRID EMT

SIMULATION INITIATIVE

Data Center Component Dynamics: Beyond IT Load

Brett Ross, Electrical Engineer

August 18th, 2026



**Pacific
Northwest**
NATIONAL LABORATORY



U.S. DEPARTMENT
of **ENERGY**

Office of
Electricity

Agenda

This presentation covers newly-enhanced EMT models for data center components and their relevant dynamics for grid-level studies.

- Library update (0:02)
- Data center component dynamics (0:12)
- Focused on components beyond IT load:
 - Cooling loads
 - Energy storage for load smoothing applications
 - Reciprocating engines
 - Example: mixed-architecture data center



Modeling Library, Beta Release

Major update available soon, based on user feedback and requests:

<https://iee-dataport.org/open-access/data-center-model-library-electromagnetic-transient-analysis-pscad>

Improvements to existing models:

- Rack-level power supply control more flexible RE: fault behavior
- Improved sophistication of UPS Vdc control during LVRT

New components:

- Complete cooling models—drive and mechanical load
- On-site generation—combustion engines

New system models:

- Benchmark with phasor model (PERC1)
- Semi-aggregated model—simulate partial tripping, curtailment, transfers

Recap:

- First released in January 2026.
- Intended to accelerate industry development of EMT models for grid-level studies of data center interconnections.
- Covers major data center equipment (UPS, rack-level power supplies, common architectures).

Also from PNNL:

PSCAD and PSSE Version of WECC
Grid-Forming Inverter Models
<https://github.com/pnnl/PSCAD-and-PSSE-Version-of-WECC-Grid-Forming-Inverter-Models>



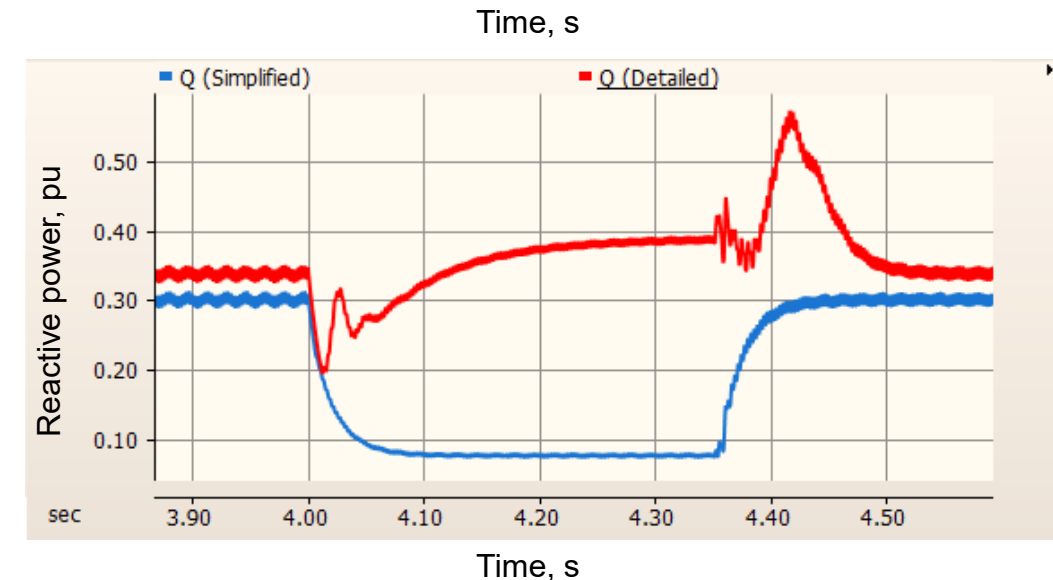
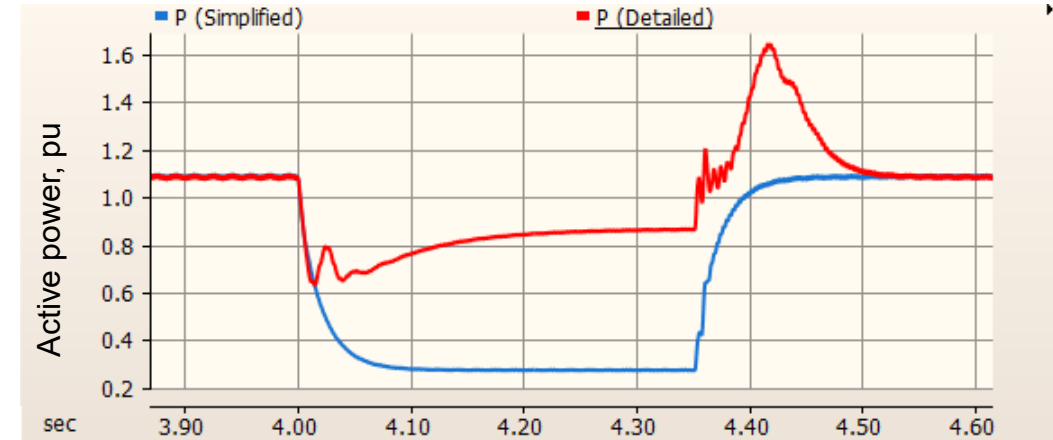
U.S. DEPARTMENT
of **ENERGY**

Office of
Electricity

Cooling Load

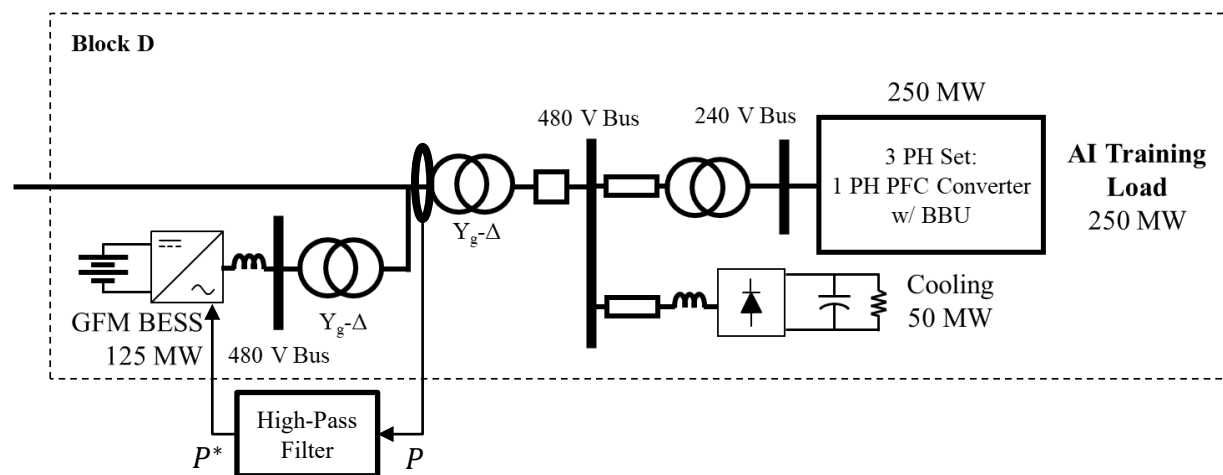
- **Simplified:** diode rectifier, RC circuit
- **Detailed:** R replaced with inverter and induction motor
- Output drive dynamics significantly affect fault response. Especially:
 - Drive size vs. mechanical load
 - Inertia of motor + mechanical load
 - Presence of LVRT-specific drive controls (e.g., flying restart, DC link charge conservation)

3 PH Fault Response

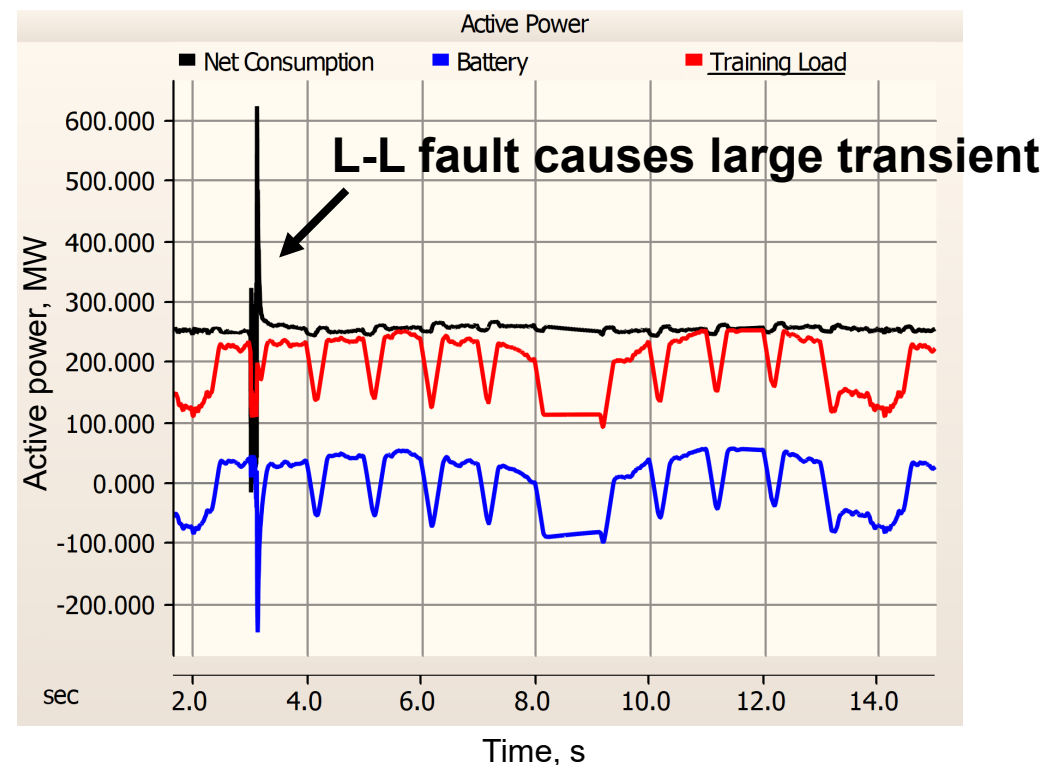


Energy Storage

- Most AC-interfaced storage will provide fault response similar to utility-scale BESS



Note: The default GFM inverter model in DML is basic and for illustration. PNNL has released more sophisticated models here: <https://github.com/pnnl/PSCAD-and-PSSE-Version-of-WECC-Grid-Forming-Inverter-Models/releases/tag/V1>



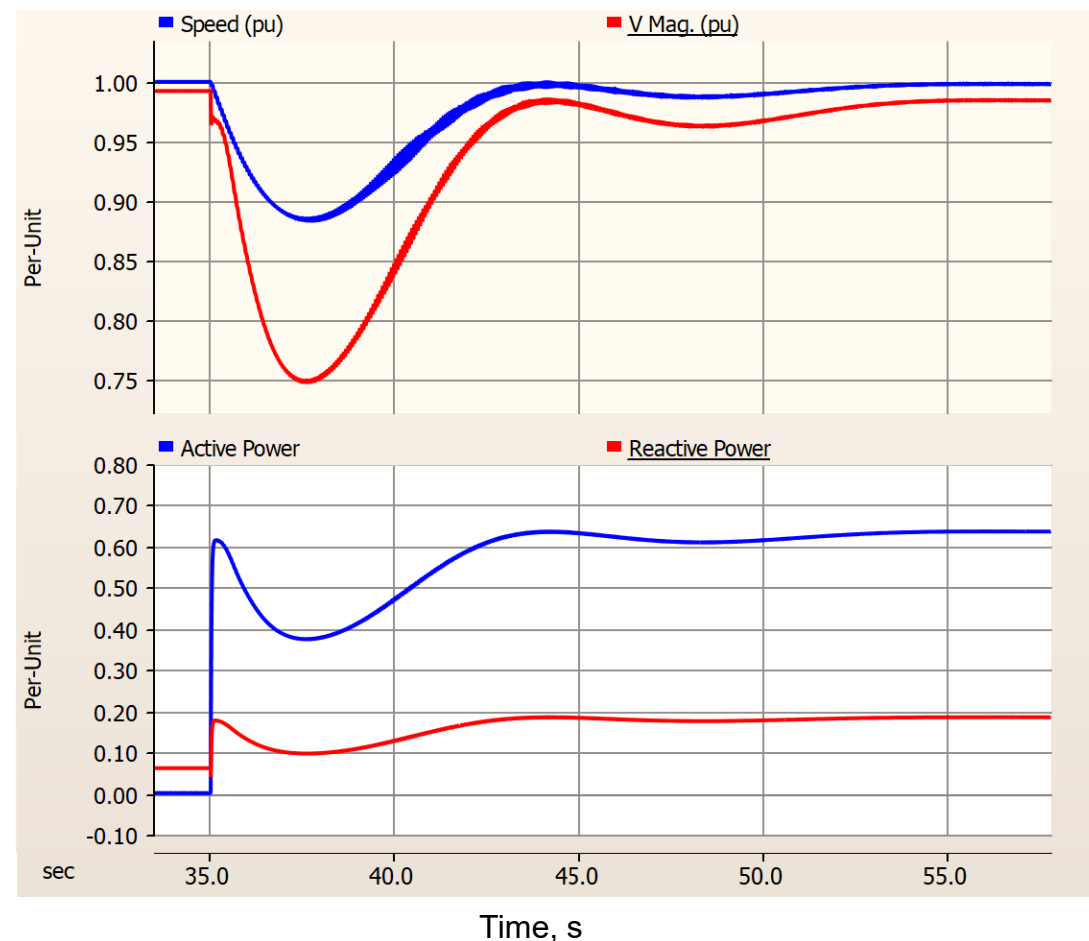
U.S. DEPARTMENT
of **ENERGY**

Office of
Electricity

Reciprocating Engine Generators

- Gas, natural gas variants increasingly looked to for bridging power with possible grid-connected operation
- Governor, excitor, prime mover dynamics all differ significantly from conventional utility-scale turbine generators

Response to 50% load step (resistive)

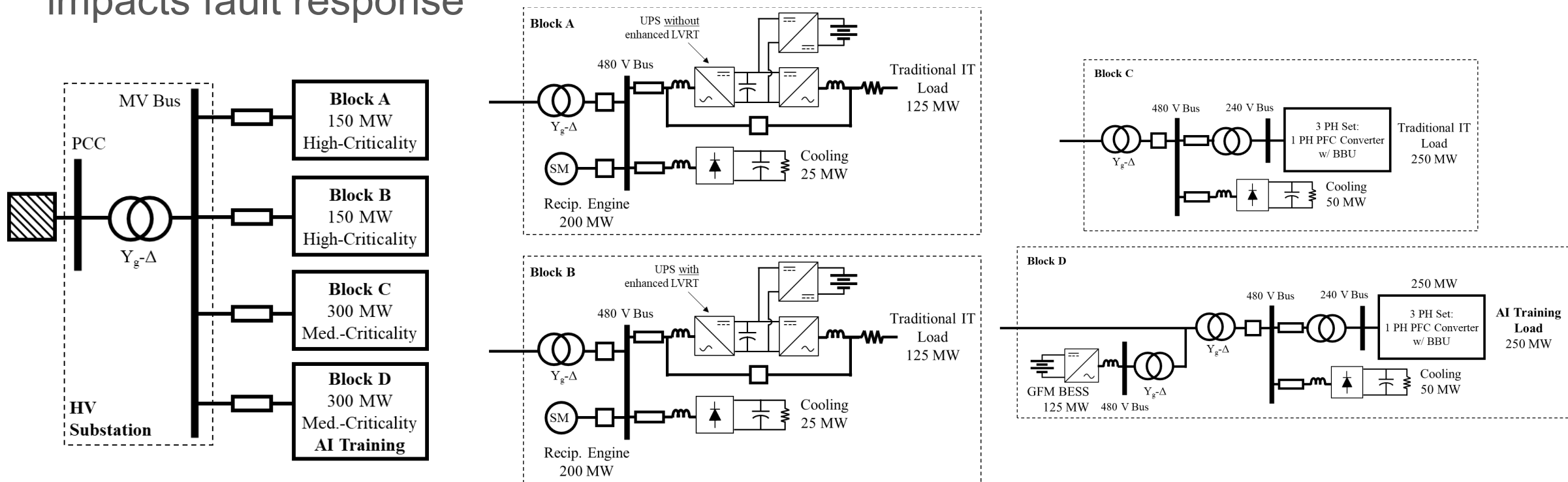


U.S. DEPARTMENT
of **ENERGY**

Office of
Electricity

Example: Mixed Architecture Data Center

- Real-world sites often non-homogenous, supporting multiple user types; this impacts fault response

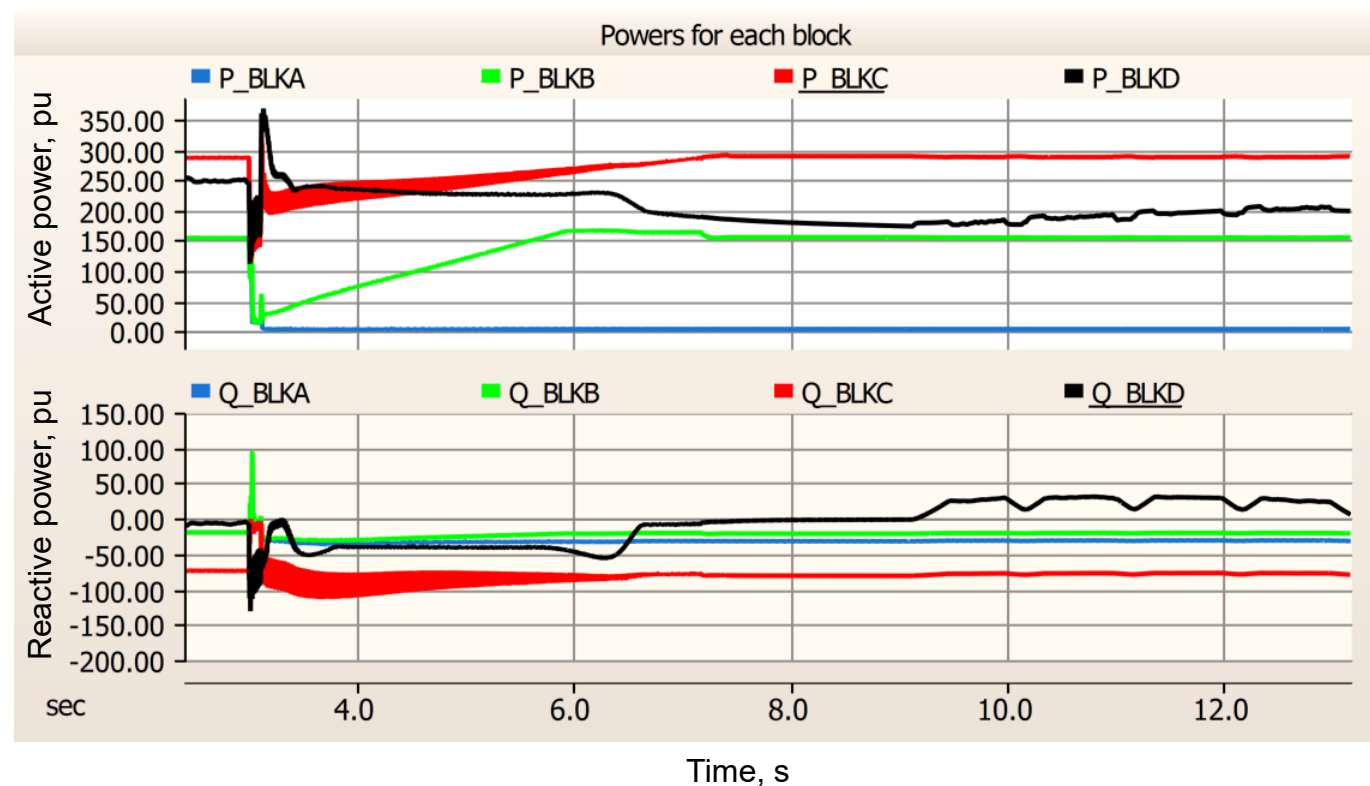
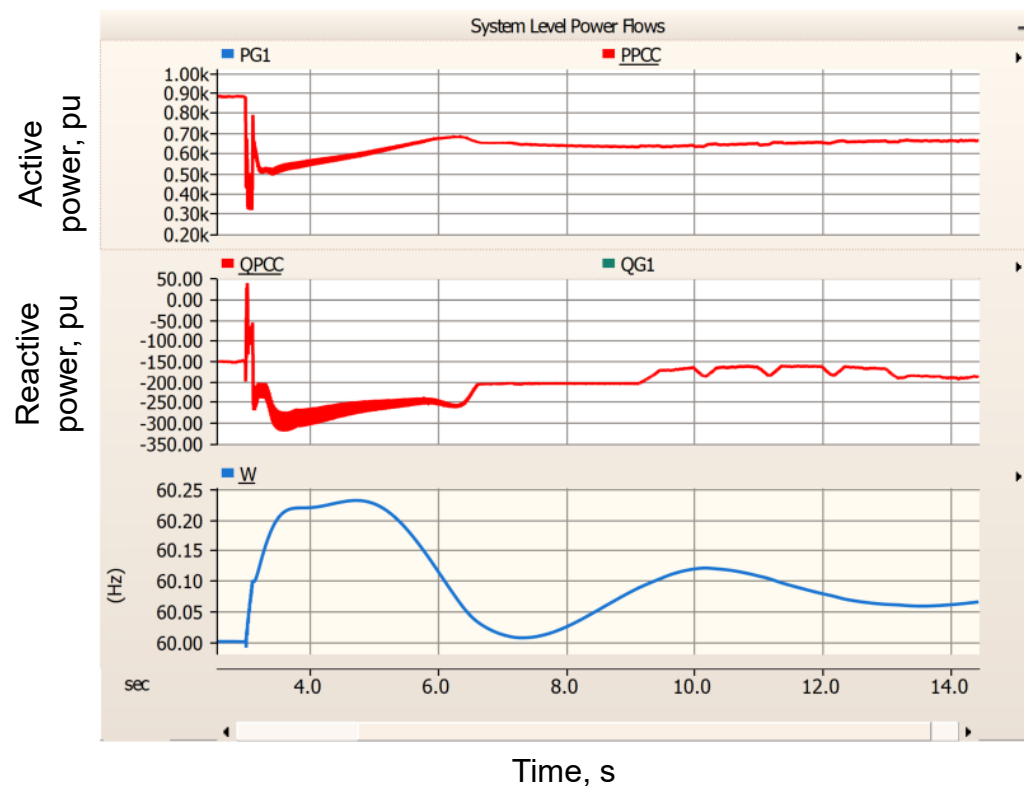


U.S. DEPARTMENT
of ENERGY

Office of
Electricity

Results: Mixed Architecture Data Center

- Consider a 100 ms L-L fault, PCC voltages down to 0.52 pu.



Conclusions

- A variety of generic EMT models for major types of data center equipment are now available.
- For real-world studies, these should be refined into product- and site-specific models
- Wide variations in site equipment type and response pose a major challenge for accurate modeling of data centers.



Thank You

Acknowledgement: The authors thank U.S. Department of Energy (DOE) Office of Electricity (OE) Advanced Grid Modeling (AGM) and the EMT initiative for their invaluable guidance and kind support in this work!

Legal Disclaimer: This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.





U.S. DEPARTMENT *of* ENERGY

Office of Electricity