

OAK RIDGE National Laboratory

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# Event Replay in RE-INTEGRATE : Experience and Its Learnings

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U.S. DEPARTMENT of ENERGY

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# EMT Initiative

Bring together national labs, academia, and industry partners under one platform to accelerate the development and use of electromagnetic transient (EMT) simulation software.

NATIONAL LABS | ACADEMIA | INDUSTRY

## Vision

Enable **industry's transition** to EMT simulation for a secure, reliable future grid through an ecosystem.

## Overall Goal

Integrate models, data, validation, standards, and workforce training.

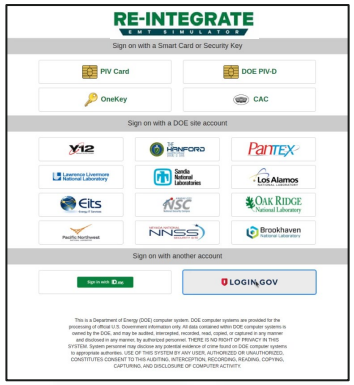
## IMPACT · NEAR-TERM

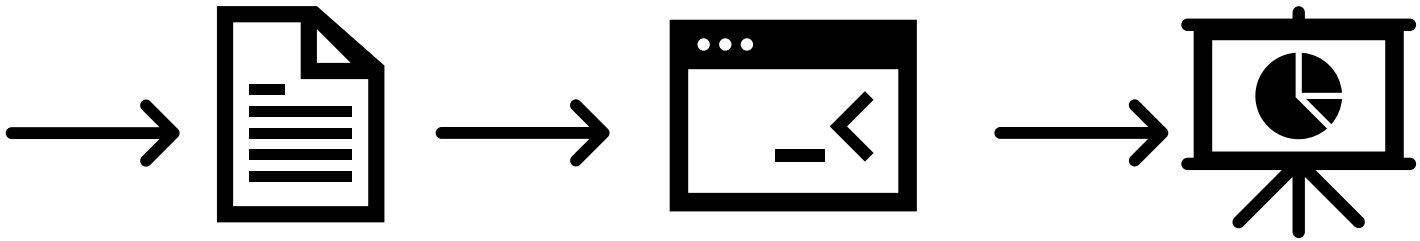
- **Faster** interconnection studies
- **Reliable** deployment of large loads and new generation
- Higher **return** on **capital** and **lower capital** expenditure

# Overview

- RE-INTEGRATE Simulator
- Event Replay with RE-INTEGRATE
- Demonstration

# RE-INTEGRATE EMT Simulator



## Authentication

- Access control
- Secure interface
- Secure Storage

## Cases

- Typical use formats (RAW, DYR, DSS, ..)
- Built-in Parsers

## EMT Simulation

- Intelligent Matrix reordering
- Multiple Solvers.

## Results

- Time-domain waveforms.
- Reports & Analytics.

**Advance Solvers** | **Detailed Model Library** | **Parallel Processing** | **Automated Workflows** | **AI Enabled**

# RE-INTEGRATE EMT Simulation: Current Capabilities

| Characteristics | RE-INTEGRATE |
|---|---|
| Solvers | **RE-INTEGRATE's structure-aware solvers (BD, BBD, BTD*), hybrid integrators (ImEx), KLU, SuperLU (mixed-precision), intelligence to select solvers/integrators Multicore/GPU-compatible** |
| Input Data Structures | **.raw**, **.dyr**, .dss, .xml, **.fau**, .seq, **.json** |
| Component Models | Generation (synchronous) + exciters + governors + PSS, HVDC, transmission lines, transformers, loads, inverters, large loads – ~100+ models available |
| Simulation Speed | •Real-time with IEEE 39-bus with 375 inverter system (demonstrated at workshop)<br>**•Speed-up of differing magnitudes with existing software (multiple publications)**<br>**•Latest benchmark: Speed-up (cumulative) of 240x observed** |
| Largest System Tested | 118,000 bus (millions of nodes)<br>125,000 inverters |
| Test Systems Examples | IEEE 9-bus, 10-bus, **IEEE 39-bus**, IEEE 118-bus, IEEE 123-bus, ActivSg200-bus, 234-bus, 390-bus, 1180-bus, 3900-bus, 11800-bus, 39000-bus, 118000-bus, real-world systems (3) – 25+ systems |
| Features | **Contingency selection**, grid strength analysis, LLM integration (with partners) |
| Applications | **MQT, RT, Integration tool** |

**Long-Term Research Goal:** Simulate 10+ million nodes with 1+ million inverters in near real-time

**Target:** Plug-and-play approach to perform interoperable research on individual modules with ease of usage, allying tools, standard models/data structures, advanced integrators/solvers, AI-infused capabilities for large-scale studies

# Live Demo

# Thank You!

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