



# Hardware-in-the-Loop (HIL) Test Services

*Zero-Emission Grid*

# Engineering the Future of **Power Grids.**

We provide advanced hardware-in-the-loop (HIL) testing services using state-of-the-art HIL equipment. We support stakeholders across the power system sector—including renewable developers, BESS developers, OEMs, utilities, consulting firms and data centers—in validating their systems to meet evolving grid requirements.

By replicating real-world conditions in a controlled environment, we help identify performance issues early, reduce deployment risks, and accelerate project timelines with confidence.



## APPLICATIONS

### **01** Utilities

ZEG provides utilities with a low-risk, high-fidelity environment to evaluate protection systems, grid control algorithms, & distributed energy integration strategies. Testing under simulated operating conditions allows utilities to validate performance & ensure grid reliability before field deployment.

### **02** Manufacturers

From inverter-based resources to energy storage systems & advanced microgrid controllers, equipment manufacturers & technology developers rely on ZEG's HIL platform to test prototypes & commercial models against the latest grid codes. Our environment supports rapid iteration, system validation, & deep performance insights.

### **03** Consulting Firms

ZEG enables engineering consultants to simulate real-world grid conditions using client hardware, allowing for precise testing of protection schemes, controller settings, & DER integration plans. This helps generate robust data for interconnection studies, utility submissions, & regulatory approvals.

### **04** Research Centers & Universities

Academic & research organizations use ZEG's HIL services to test experimental control strategies, communications frameworks, & cybersecurity protocols. Our platform provides a safe, flexible setting for advancing innovation without the risks of live grid interaction.

## OUR VALUES



Accessibility



Integrity



Accountability



Expertise



Collaboration

# Why renewable energy leaders choose ZEG.

### END-TO-END TECHNICAL SUPPORT:

Beyond HIL testing, ZEG offers integrated engineering, simulation, & analytics services. With deep familiarity across ISO, RTO, NERC, & IEEE frameworks, we deliver comprehensive reports & guidance to streamline compliance & accelerate project readiness.

### TECHNICAL & REGIONAL EXPERTISE:

Our engineers bring specialized experience in power systems & HIL testing. With decades of combined expertise, we ensure efficient execution, accurate analysis, & reliable insights.

### TESTING TAILORED TO YOUR PROJECT:

We kick off with a custom testing plan built around your project's unique technical requirements. We collaborate closely with you to replicate specific grid conditions, disturbances, & fault scenarios—for results that are relevant & actionable.

### CUTTING-EDGE INFRASTRUCTURE:

We ensure accurate validation of equipment performance with access to the latest Real-Time Digital Simulators (RTDS) & a broad suite of protection relays—enabling precise, hardware-in-the-loop (HIL) testing under realistic grid conditions.



## Project Scoping



The process begins with a consultation to understand the client's objectives, hardware specifications, & testing goals. This includes discussing grid scenarios, operating conditions, & any applicable standards.

## Test Plan Development



We develop a detailed test plan outlining the simulation environment, hardware setup, communication interfaces, & specific test cases. Clients review & approve the plan before implementation begins.

## Lab Integration



The client's hardware is connected to the RTDS platform (& protection relays if necessary). We ensure that communication & electrical connections between the devices match the requirements, & we configure the simulation environment to reflect the client's specific needs.

## HIL Testing



Tests are executed in real time, with engineers monitoring hardware behavior & collecting data. Additional test cases can be introduced during this phase, depending on client feedback or observations.

## Reporting, Compliance Assessments & Follow-Up



After testing, we provide a comprehensive report with key findings, performance metrics, & analysis. Where applicable, the report also includes compliance assessments (e.g., NERC/IEEE/ISO/RTO), mitigation strategies, & technical recommendations. Follow-up sessions are available to review results &, if needed, plan additional rounds of testing.

## 01 Power Electronics Controller Testing

We provide testing services for control systems used in power electronic devices such as inverters, STATCOMs, & HVDC converters. By connecting the physical controller to a simulated grid environment on the RTDS, we can evaluate its response to a wide range of grid conditions, including voltage disturbances, frequency events, & faults. The communication interface between the controller & the simulation can be configured to match client requirements, e.g., Modbus.

## 02 Protection System Validation

We test protection relays by connecting them to simulated power systems in the RTDS. The interface between the relay(s) & the simulator uses the IEC 61850 protocol, allowing for precise & realistic testing of modern digital protection schemes. The RTDS sends the real-time measurements, breakers' status, etc., to the relays & receives a number of signals (such as the pick-up & trip signals) from the relay(s) to reflect the protection scheme behavior in the simulation.

## 03 DER & Microgrid Control Testing

We test controllers used for distributed energy resources (DERs) & microgrids by interfacing them with real-time simulated grid environments. The simulated environment can include both grid-connected & islanded scenarios, in which events like faults, voltage fluctuations, & load changes occur. The setup allows us to assess how the controller manages coordination, stability, & transitions between operating modes under realistic conditions.


## 04 Digital Substation & IEC 61850 Testing


We simulate digital substations to test devices that rely on IEC 61850 communication, such as merging units, IEDs, & protection relays. Using real-time scenarios in the RTDS, we evaluate how these devices exchange messages like GOOSE & Sampled Values during normal operation & fault conditions.

## 05 Cybersecurity Assessment of Power Systems

We simulate cyber-attacks & communication failures to test how control & protection systems respond under compromised conditions. Scenarios can include denial-of-service, spoofing, or loss of communication. This helps assess system resilience & supports the development of mitigation strategies before deployment.

**CONTACT US TODAY!**

 [info@zeroemissiongrid.com](mailto:info@zeroemissiongrid.com)

 [www.zeroemissiongrid.com](http://www.zeroemissiongrid.com)